



TRANSACTIONS  
AND  
PROCEEDINGS  
OF THE  
NEW ZEALAND INSTITUTE

VOL. 58.  
(QUARTERLY ISSUE)

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OF GOVERNORS OF THE INSTITUTE

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## NEW ZEALAND INSTITUTE.

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### NOTICE TO MEMBERS.

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THE PUBLICATIONS of the New Zealand Institute consist of—

1. *Transactions*, a yearly volume of scientific papers read before the local Institutes. This volume is of royal-octavo size.
2. *Proceedings*, containing report of the annual meeting of the Board of Governors of the New Zealand Institute, abstracts of papers dealing with New Zealand scientific matters and published elsewhere, list of members, &c. The *Proceedings* are of the same size as the *Transactions*, and are bound up with the quarterly numbers of *Transactions* supplied to members.
3. *Bulletins*. Under this title papers are issued from time to time which for some reason it is not possible to include in the yearly volume of *Transactions*. The bulletins are of the same size and style as the *Transactions*, but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

**LIBRARY PRIVILEGES OF MEMBERS.**—Upon application by any member to the Librarian of the New Zealand Institute or of any of the affiliated Societies such works as he desires to consult which are in those libraries will be forwarded to him, subject to the rules under which they are issued by the Institute or the Societies. The borrower will be required to pay for the carriage of the books. For a list of the serial publications received by the Library of the New Zealand Institute during 1927, see pp. 605-614.

**ADDRESSES OF MEMBERS.**—Members are requested to notify the Secretary of any change of address, so that the same may be noted in the List of Members.



## MEMORANDUM FOR AUTHORS OF PAPERS.

THE attention of authors is particularly directed to the following instructions, the observance of which will greatly aid the work of both Editor and printer. It is of importance that in typewritten as well as other copy ample space should be left between the lines.

1. All papers must be typewritten, unless special permission to send in written papers has been granted by the Editor for the time being. Wide spacing between the lines and ample margin should be left.

2. The author should read over and correct the copy before sending it to the Editor of the *Transactions*.

3. A badly arranged or carelessly composed paper will be sent back to the author for amendment. It is not the duty of an editor to amend either bad arrangement or defective composition.

4. In regard to underlining of words, it is advisable, as a rule, to underline only specific and generic names, titles of books and periodicals, and foreign words.

5. In regard to specific names, the International Rules of Zoological Nomenclature and the International Rules for Botanical Nomenclature must be adhered to.

6. Titles of papers should give a clear indication of the scope of the paper, and such indefinite titles as, *e.g.*, "Additions to the New Zealand Fauna" should be avoided.

7. Papers should be as concise as possible.

8. Photographs intended for reproduction should be the best procurable prints, unmounted and sent flat.

9. *Line Drawings*.—Drawings and diagrams may be executed in line or wash. If drawn in line—*i.e.*, with pen and ink—the best results are to be obtained only from good, firm, black lines, using such an ink as Higgin's liquid India ink, or a freshly mixed Chinese ink of good quality, drawn on a smooth surface, such as Bristol board. Thin, scratchy, or faint lines must be avoided. Bold work, drawn to about twice the size (linear) of the plate, will give the best results. Tints or washes may not be used on line drawings, the object being to get the greatest contrast from a densely black line drawn on a smooth, white surface.

10. *Wash Drawings*.—If drawing in wash is preferred, the washes should be made in such water-colour as lamp-black, ivory black, or India ink. These reproduce better than neutral tints, which inclines too much to blue in its light tones. High lights are better left free from colour, although they may be stopped out with Chinese white. As in

line drawings, a fine surface should be used (the grain of most drawing-papers reproduces in the print with bad effect), and well-modelled contrasted work will give satisfactory results.

11. *Size of Drawings.*—The printed plate will not exceed 7½ in. by 4½ in., and drawings for plates may be to this size, or preferably a multiple thereof, maintaining the same proportion of height to width of plate. When a number of drawings are to appear on one plate they should be neatly arranged and if numbered or lettered in soft pencil the printer will mark them permanently before reproduction. In plates of wash drawings, all the subjects comprising one plate should be grouped on the same sheet of paper or cardboard, as any joining-up shows in the print. Text-figures should be drawn for reduction to a width not exceeding 4½ in. If there are a number of small text-figures they should be drawn all for the same reduction, so that they may be arranged in groups.

12. *Maps.*—A small outline map of New Zealand is obtainable at a low price from the Lands and Survey Department, Wellington, upon which details of distribution, &c., can be filled in according to the instructions given above for line drawings.

13. *Citation.*—References may be placed in a list at the end of an article or arranged as footnotes. The former method is preferable in long papers. In the list references are best arranged alphabetically, reference in the text being made by writing after the author's name, as it occurs, the year of publication of the work, adding, if necessary, a page number, and enclosing these in parentheses, thus: "Benham (1915, p. 176)." Example of forms of citation for alphabetical list:—

BENHAM, W. B., 1915. *Oligochaeta from the Kermadec Islands*, *Trans. N.Z. Inst.*, vol. 47, pp. 174-85.

PARK, J., 1910. *The Geology of New Zealand*, Christchurch, Whitcombe and Tombs.

When references are not in alphabetical order the initials of the author should precede the surname, and the year of publication should be placed at the end. Care should be taken to verify the details of all references—date, pages, &c.—and initials of authors should be given.

14. In accordance with a resolution of the Board of Governors, authors are warned that previous publication of a paper may militate against its acceptance for the *Transactions*.

15. In ordinary cases twenty-five copies of each paper are supplied gratis to the author, and in cases approved of by the Publication Committee fifty copies may be supplied without charge. Additional copies may be obtained at cost price.

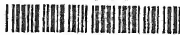
## E R R A T A .

Page 114, lines 8 and 18: for Centropagiae read Centropagidae.

Page 122, line 9 from foot: for "corresponding parts of the maxillae" read "lower lip."

Page 123, line 4 from foot: for "setate" read "setae."

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# PROCEEDINGS

OF THE

## NEW ZEALAND INSTITUTE,

### 1927.

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#### MINUTES OF ANNUAL MEETING OF THE BOARD OF GOVERNORS,

27th JANUARY, 1927.

The Annual Meeting of the Board of Governors was held in Victoria University College, at 10 a.m., on Thursday, 27th January, 1927.

Present—Representing the Government: Mr. B. C. Aston (President); Professor Chilton, Dr. L. Cockayne, and Dr. J. A. Thomson.

Representing Auckland Institute: Professor H. W. Seager, Professor F. P. Worley.

Representing Wellington Philosophical Society: Mr. G. V. Hudson and Professor H. B. Kirk.

Representing Philosophical Institute of Canterbury: Dr. C. C. Farr and Mr. A. M. Wright.

Representing Otago Institute: Professor J. Park and Hon. G. M. Thomson.

Representing Hawke's Bay Philosophical Institute: Mr. H. Hill.

Representing Manawatu Philosophical Society: Mr. M. A. Elliott.

Representing Nelson Institute: Professor T. H. Easterfield.

Dr. Marshall, Hon. Secretary. The Hon. Editor attended for a period in the afternoon.

*Apologies for absence* were received from His Excellency the Governor-General, and from the Hon. Minister of Internal Affairs, Mr. Bolland.

*Notices of Motion.*—These were received and set down for discussion in the afternoon.

*Presidential Address.*—Mr. B. C. Aston delivered his presidential address. Professor Farr moved that the President be thanked for his address, and be asked to allow it to be printed in the Transactions. Seconded by Prof. Chilton and carried unanimously.

*Hector Award.*—The president announced that owing to the absence of the two gentlemen appointed to make the Hector Award,

a final decision had not yet been made. On the motion of Mr. Elliott, seconded by Professor Chilton, it was resolved that the award of the Hector Medal be made by the Standing Committee on receipt of a report from the Hector Award Committee appointed at last Annual Meeting. The amount of the prize to be £45.

*Fellowship, N.Z. Institute.*—The election was then held, and the Hon. Returning Officer, Prof. Segar, announced that Mr. W. R. B. Oliver and Mr. H. D. Skinner had been elected Fellows.

## REPORT OF THE STANDING COMMITTEE FOR THE YEAR ENDING 31st DECEMBER, 1926.

*MEETINGS.*—During the year 10 meetings of the Standing Committee have been held, the attendance being as follows:—Mr. B. C. Aston, Wellington, President, 10; Dr. J. A. Thomson, Wellington, 9; Mr. G. V. Hudson, Wellington, 9; Professor Kirk, Wellington, 8; Dr. Cockayne, Ngāio, 7; Hon. Editor, Wellington, 7; Hon. Secretary, Wellington, 5; Mr. M. A. Elliott, Palmerston North, 3; Dr. C. C. Farr, Christchurch, 3; Hon. G. M. Thomson, Dunedin, 2; Mr. A. M. Wright, Christchurch, 2.

*PUBLICATIONS.*—Volume 56 was issued from the Government Printing Office in August, and was laid on the tables of the House of Representatives and of the Legislative Council on the 10th and 11th August respectively.

*Dixon's Bulletin* on the Byrology of New Zealand, Part 4, has now been issued, and on the 2nd November the Standing Committee authorised the publication of Part 5 at a cost not to exceed £30.

*Printing Transactions.*—At last annual meeting the Standing Committee was instructed to call for tenders under specification for the printing of the Transactions. Authority was given the Committee to accept any tender, not necessarily the lowest, and to make such arrangements as it deemed necessary for the expeditious publication of the Volume. On the 25th March specifications which had been drawn up by the President and Hon. Editor were adopted, and it was decided that copies should be sent to approved publishers. Tenders were received from six firms, that of Messrs. Ferguson and Osborn being the lowest. These tenders were placed before the Standing Committee on the 11th May, and after some discussion it was resolved that the Hon. Treasurer with the co-operation of Dr. Thomson, be asked to report on the financial position in order that a definite statement should be placed before the Hon. Minister of Internal Affairs and the Hon. Minister in charge of the Printing Office, when they were approached in regard to the contemplated change of printers. This report was presented at a meeting held on the 21st May, and as the result the following resolution was passed:—"That the Committee meet the Hon. Minister of Internal Affairs and the Hon. Minister of the Printing Office and offer to pay off the debt on the Transactions in four years in accordance with the report drawn up by the Hon. Treasurer, and provided the consent of the Ministers be obtained, the tender of Messrs. Ferguson and Osborn for the printing of the Transactions quarterly for three years be accepted, but as the material for Volume 57 is now in hand that volume be issued in one volume." On the 2nd June the President reported that the deputation had waited on the Ministers, and they had agreed to the proposals contained in the above resolution. The Hon. Mr. Anderson stated that interest at the rate of 5 or 6 per cent. would be charged on overdue account. Subsequently a signed letter of agreement was drawn up with Messrs. Ferguson and Osborn providing (1) that the first volume of the Transactions (No. 57) be in one volume on the paper submitted as specimen; (2) that subsequent issues be in one volume or parts at the option of the Institute; (3) that progress payments be made as the printing of the volume proceeds; (4) that the tender of Messrs. Ferguson and Osborn be accepted only for one year at first, and that agreement for

three or five years may be made subsequent to the issue of Volume 57, and providing this agreement is signed, the cost of volume 57 shall be the same as if such agreement were in force from the beginning; (5) should any unforeseen circumstance warrant it a fair increase of prices may be charged on submitting reasons for the same to the Institute which will agree to such an increase should the reasons seem good and valid; or, failing the receipt of the full Government vote, the New Zealand Institute may terminate the contract.

The signed agreement included also the specifications and the tender of Messrs. Ferguson and Osborn.

The Hon. Minister of Internal Affairs had expressed a desire to see the above agreement, and on a copy being submitted to him he forwarded a favourable confidential report to the Institute.

VOLUME 57 is still in the press at the date of this report, but the publishers hope that it will be out before the annual meeting.

PAPERS FOR TRANSACTIONS.—On the 2nd June it was resolved that after a paper has been set up, the author will be required to pay for any additions and that before handing over the papers for Volume 57 to the printer they be sent back to the authors for final revision. It was further resolved on the 8th July, that if in the opinion of the Hon. Editor the manuscript is not suitable for the printer, it be returned to the author, and if not amended to the Hon. Editor's satisfaction, it be declined.

*Finance Clause in Institute Act.*—Last year the Under-Secretary for Internal Affairs wrote stating that provision had been made in Section 7 of the Finance Act, to pay to the Institute £1500 yearly, and that the New Zealand Institute Amendment Act, 1920, had been repealed. At a meeting of the Standing Committee on the 21st May, it was resolved to ask the Minister of Internal Affairs to have the New Zealand Institute Amendment Act and Section 7 of the Finance Act consolidated. This matter was brought before the Hon. Minister at the deputation which waited on him in regard to publication matters.

*Incorporated Societies' Reports and Balance Sheets.*—The following reports and balance-sheets have been received and are now laid on the table:—Philosophical Institute of Canterbury for the year ending 31st October, 1926; Wellington Philosophical Society for the year ending 30th September, 1926; Auckland Institute for the year ending 5th February, 1926; Nelson Philosophical Society for the year ending 31st October, 1926; Hawke's Bay Philosophical Institute for the year ending 31st December, 1926; Otago Institute for the year ending 30th November, 1926. The Hon. Treasurer, on the 20th March, forwarded a statement showing the position of the incorporated societies. No report was available from Manawatu Philosophical Society.

*Sales: Maori Art.*—In view of the exceptionally heavy demand for Maori Art during 1925, the Standing Committee considered it expedient to raise the price to £6/6/- per set. This year, however, the sales of Maori Art have returned to normal but with the setting up of the Maori Crafts School at Rotorua there will possibly be in the future an increased demand. It was decided to order a limited number of covers to be made, the original stock being exhausted. Messrs. Whitcombe & Tombs executed the order and complete sets with original rafter pattern cover are now available at £10/10/- per set.

*Bulletins.*—The bulletins in stock do not produce a ready sale, only about half-a-dozen being sold during the year.

*Carter's Books.*—The Carter Revenue Account has been increased by £12/5/2 by sales of "Life of a New Zealand Colonist" and "New Zealand Loans."

*Partial Sets.*—A partial set of the Transactions was presented to the French Academy of Sciences through the French Consul at Auckland.

*Hector Award.*—The Hector Award for 1926 was made to Mr. H. D. Skinner, of Otago, for his research in Ethnology. At a meeting of the Otago Institute held on the 14th September, the medal and prize were presented to Mr. Skinner by the President of the Otago Institute acting on behalf of the President of the New Zealand Institute.

*Hutton Award.*—The Convener of the Hutton Award Committee, Dr. Benham, forwarded on April 9th the recommendation of his Committee as follows:—"As a result of careful consideration of the merits of various botanists, geologists, and zoologists, we are of opinion that the medal should be awarded to Professor Charles Chilton, M.A. D.Sc., for his continuous researches on the Amphipodous Crustacea of New Zealand, with special reference in his recent publications to the geographical relations of the Dominion to other Southern lands, as indicated by the distribution of representatives of this group." At a meeting of the Philosophical Institute of Canterbury, on the 16th October, the Hutton Medal was presented to Dr. Chilton by Mr. Aston, President of the New Zealand Institute.

*Hamilton Memorial Prize.*—The prize for 1926 was awarded to Dr. Marwick and to Mr. H. J. Finlay, who were considered by the Hamilton Prize Committee to be equally deserving of the prize. At the Annual Meeting of the Wellington Philosophical Society the prize was presented to Dr. Marwick by Dr. J. A. Thomson and Mr. Findlay was presented with the prize at a meeting of the Otago Institute on September 14th by the President of the Otago Institute.

*Fellowship.*—The New Zealand Gazette of 22nd April, 1926, notified that Professor W. N. Benson, B.A., D.Sc., F.G.S., and J. S. MacLaurin, D.Sc., F.C.S., had been elected to the Fellowship of the New Zealand Institute.

On the 19th May, incorporated societies were asked to forward nominations for two vacancies in the Fellowship for 1927. Ten nominations were received and were submitted to the Fellows for selection. On the 23rd September, the Honorary Returning Officer announced the names of the first three selections, and that three others had tied for fourth place. A fresh election for this place was therefore held, and on the 26th October the result was notified, and the four names submitted to the members of the Board of Governors for election at the Annual Meeting.

*Research Grants.*—There was a small unallocated balance remaining from last year's research vote, and on the 9th February incorporated societies were notified to this effect. Five applications were received and approved. On the 6th August an intimation was received from the Under-Secretary Internal Affairs that £1000 for research had been placed on the Estimates for the year. Applications for grants were called for on the 16th August, and twelve were received. Of these, seven have, so far, been granted, one is deferred for further information, and four have not been recommended by the Research Committee. The total amount of grants made during the year is £680. This £1000 is only sufficient to cover existing liability.

*Professor Speight's report.*—At last Annual Meeting it was resolved to request the Minister of Mines to publish Professor Speight's report on the Geology of the Malvern Hills as a Bulletin of his Department. The Minister replied on the 6th April that he considered it inadvisable to give effect to the Institute's request. Professor Speight was then informed that he was at liberty to take any steps he wished to have the report published. He replied that there was little chance of his report being accepted for publication elsewhere, and he should therefore prefer to leave it in the hands of the Standing Committee.

*Library Matters: Binding.*—During the year 24 volumes, all New Zealand publications, were bound, and on the 2nd November, on the recommendation of the Library Committee, it was resolved that the following series be bound as far as funds permit:—The Royal Societies of Edinburgh, of New South Wales, and of Victoria, the Geological Survey of India, the Linnean Society of New South Wales, and the United States Journal of Agricultural Research. These sets are in course of preparation for the binder.

*Current Literature.*—In order to extend the usefulness of the Library, a circular was issued on the 30th October to Institute members stating that if desired there would be sent to members on short loan current literature dealing specifically with the subject of their research work. Some members are enthusiastic about the usefulness of this proposal in saving their time and keeping them abreast of the latest literature on their special subjects.

*Exchange List.*—On the recommendation of the Library Committee the Exchange List was, on the 2nd November, augmented by the addition of the following:—Inst. Botanico, Coimbra; Marine Biological Laboratory, Woods Hole, Mass.: "Gaea" (Argentine Society of Geographical Studies); Musee Polonaise d'hist. nat., Warsaw; Museum, Tromsø, Norway; Ac. Scient. Veneto-Trentino, Padova; Comité Geol. de Russie, Leningrad; Californian State Fisheries Laboratory; Rijks Geol. Mineral Museum, Leiden; University of Oregon; Wiss. Akademie, Bremen.

*Reference List of Periodicals.*—The Standing Committee was empowered at last Annual Meeting to have this list published. Quotations for printing were received, and it was ascertained how many copies would approximately be required by libraries, societies, etc., at a cost of 5/-. Applications for over 70 copies were received. At a meeting of the Standing Committee held on the 8th July, a suggestion was received from the Wellington Philosophical Society that the Reference List be published in the Journal of Science and Technology. After due consideration Dr. Thomson reported that this would not be practicable, and on the 3rd September the Standing Committee resolved to accept the tender of Messrs. Ferguson and Osborn for printing 250 copies. The list is now in the printer's hands, and will be published as soon as Volume 57 has been completed.

*Tongariro National Park.*—At a meeting of the Standing Committee held on the 2nd June, the President reported that the Agenda Paper of the Park Board Meeting included a proposal to rescind the motion regarding the eradication of heather. The following resolution was forwarded to the Chairman of the Board and to the Hon. Minister of Lands:—"That if this motion be rescinded the whole motive for making the National Park will be upset."

At a meeting of the Standing Committee on the 8th July, the President reported that consideration of questions regarding heather, liberation of game birds, and leasing of sections, had been deferred until the next meeting of the Board in six months' time. The President then read the following statement as expressing the policy of the New Zealand Institute:—

"That this Standing Committee of the New Zealand Institute Board of Governors expresses satisfaction at the increased interest which is being taken by the various public societies and the public generally in the development of the Tongariro National Park as a field for public recreation.

"That this meeting, being directly represented on the National Park Board, and therefore officially entitled to speak on the management of the scientific amenities of the Park, now formally sets out the following policy in such matters:—

"The New Zealand Institute considers that the flora and fauna of the Park should be protected against the competition of any plant or animal foreign to this Park, and to this end the Institute seeks to prohibit the encouragement of any foreign plant or animal to make its home in the Park. This Institute is strongly hostile to the introduction of foreign game birds or animals, and to plants which would be necessary as food for them.

"In formulating this policy this Institute is guided by the example of the United States of America and the Swiss authorities in the management of the National Parks in those countries.

"The guiding principle in the development of the Park should be that the natural features are preserved with only that alteration that the passage of time effects, and that the wild life, both plant and animal, are protected so that the Park will afford for all time to the native-born an example of primitive New Zealand.

"In conformity with this policy the New Zealand Institute (1) strongly opposes the granting of leases of any portion of the Park to private individuals; (2) the milling of any timber within the Park; and (3) urges that where permission is granted to Acclimatisation Societies or other bodies to import foreign plants or animals to New Zealand, the authority granting the permit does so on the understanding that plants or animals are liberated in districts remote from National Parks."

The above statement was unanimously adopted by the meeting, and it was decided that it be circulated to incorporated societies and other interested public bodies and published in the press. This was done, and letters were received from numerous bodies endorsing the policy of the Institute, and the Press has throughout been most sympathetic.

On the 9th October there appeared in the "Evening Post" a statement that 13 grouse, the gift of Lady Liverpool to the Prime Minister, were liberated in the Park. The matter was immediately taken up by the Institute and a strong protest was made to the Minister against the release of the birds in the Park or in the Waimarino County. The Minister replied that permission had not been given to liberate the birds in the National Park, but in part of the Waimarino Acclimatisation District outside the Park! On the 2nd November the Standing Committee resolved to reply to the Minister stating that the Institute's letter anticipated the action of liberating the grouse in the Waimarino District, and it regarded this as a distinct violation of the spirit of the Park Board's regulations. The Minister replied on the 12th November that the resolution had been duly noted.

*Guide Book.*—A guide book to the Park is in course of preparation, and on the 8th July it was resolved to give any assistance possible in the scientific portion of it.

*Scenery Preservation Bill.*—On the 3rd September, the Hon. G. M. Thomson, M.L.C., reported that he had had a clause drafted and moved as an amendment to the Scenery Preservation Bill and the Peel Forest National Park Bill, but they were rejected by the Legislative Council, and there was no Bill before the House to which the clause covering all National Parks could properly apply.

*Native Bird Protection: Whitney Expedition.* At last Annual Meeting in Dunedin a resolution was passed and telegraphed to the Hon. Minister of Internal Affairs asking that, if not too late to do so, a representative should be sent with the Whitney Expedition to supervise the collecting of native birds under the permit which had been issued. The Minister replied that he had decided that in future no permits will be granted to visitors to take native birds except on condition that a Government Officer having a knowledge of native birds accompany the expedition, and that the expenses of such officer must be born by the person to whom the permit is issued. Further, that where a permit might be given to a New Zealand collector it will be in such collector's name only, and will not, as at present, authorise the collector or his servants acting under his written authority to take birds.

On the 4th February he intimated that arrangements had been made whereby Mr. Oliver, of the Dominion Museum, would accompany the collector of the Whitney Expedition. This arrangement, however, was never carried out. The Hon. G. M. Thomson forwarded a letter which he had received from the Hon. Minister of Internal Affairs in regard to the issue of the permit to the Whitney Expedition, and this was discussed by the Standing Committee. A reply was sent to the Minister stating that in the opinion of the Standing Committee the present regulations do not go nearly far enough towards the preservation of the fast-vanishing land-birds of the Dominion, and it therefore suggested that regulations be drawn up absolutely protecting certain birds (which were listed). The Minister replied on the 1st June that the Institute's request had been noted for consideration in the event of any application being received for permission to take specimens of any of the birds mentioned. At the same time he intimated that in future

no permits to take native birds will be granted to persons not resident in the Dominion, and if at any time it is decided to supply specimens to persons or institutions outside the Dominion, such specimens will be taken only by Government Officers. This letter was received by the Committee with satisfaction.

*Sea Shags.*—On the 3rd September a letter was received from an Auckland Committee engaged in an ecological survey of the Waitemata Harbour protesting against the Auckland Acclimatisation Society's request to the Government to take steps to destroy sea shags. It was resolved that the statements in the letter be supported, and that copies of the letter be forwarded to the Fisheries Department, the Under-Secretary of Internal Affairs, and to the Press. On the 2nd November it was resolved to ask Mr. E. F. Stead to place his views on the matter before the Institute. Mr. Stead has now sent in a report which "he trusts may be of some use to the Institute in its efforts to stop the senseless destruction of these birds."

*Auckland Islands.*—A resolution of last Annual Meeting expressing regret that the Auckland Islands had been leased was forwarded to the Hon. Minister of Lands, who replied on the 8th March that the Auckland Islands had been held almost continuously under lease since 1895, and the present lease does not expire until 1932. The Standing Committee resolved to ask the Minister to endeavour to induce the present lessees to surrender their rights, but he replied that there was little possibility of Messrs. Moffett Bros. agreeing to this proposal.

*Science Congress, Dunedin.*—On the 25th March the Minute Book of the Science Congress in Dunedin was received from the Hon. Secretary, Rev. Dr. Holloway, and it was resolved that Dr. Holloway be thanked for the valuable and successful work he did in connection with the Congress.

The Minutes of the Congress are being printed in Volume 57.

*Pan-Pacific Science Congress, 1926.*—On the 18th February incorporated societies were notified that four single or two double fares would be provided by the National Research Council of Japan for New Zealand delegates to the Congress, and they were asked to ascertain the names of their members who desired to attend. Representations were made to the Government to send a New Zealand representative, whose expenses would be defrayed by the Government, and Dr. Marshall was recommended by the Institute as Government representative. On the 14th August it was intimated by the Internal Affairs Department that Dr. Marshall had been appointed Government Representative. On the 2nd June Dr. Marshall, Prof. Benson and Prof. Macmillan Brown were appointed to represent the Institute at the Congress. The President of the Pan-Pacific Congress wrote on the 5th July that he was forwarding one double fare, and in the event of the Institute sending five or six delegates a second fare would be provided. At a meeting of the Standing Committee held on the 3rd September, it was resolved to vote the first fare to Prof. Benson, and also to appoint Mrs. Benson a delegate of the Institute. On the 16th September Dr. C. C. Farr was appointed to be the fifth delegate and the second fare was voted to him.

*Pan-Pacific Science Congress, 1929.*—On the 12th June the Auckland Institute wrote asking the New Zealand Institute to submit to the Government a proposal to hold the next Pan-Pacific Congress in Auckland. This matter was discussed by the Standing Committee on the 8th July, and it was resolved to forward the proposal to the Government for consideration. The Hon. Minister of Internal Affairs replied on the 15th September that the matter had received the careful consideration of Cabinet, and it had been decided that it is not opportune to have the next Conference in New Zealand.

At a meeting of the Standing Committee held on the 16th September, it was decided to refer the matter to Dr. Marsden, of the Scientific and Industrial Research Department. Dr. Marsden approached the Hon. Minister, who reaffirmed that Cabinet had decided against the proposal.

*Sir Frank Heath's Visit.*—As a result of a resolution passed at the last annual meeting to the effect that as the New Zealand Institute largely per-

forms the functions performed by Boards of Scientific and Industrial Research in other countries it should be represented on the Committee set up to confer with Sir Frank Heath, the Under-Secretary wrote stating that the Committee would be pleased to have Dr. Marshall, as the representative of the Institute on that committee.

A Conference between Sir Frank Heath and the Standing Committee was held on the 2nd March. On the 2nd June Sir Frank Heath's report was placed before the Standing Committee, and it was resolved: "That the New Zealand Institute offer its services to the Government to form a National Research Council as recommended by Sir Frank Heath, provided the Government pays the subscription to the International Research Council and any other expenses incurred." Further: "That in view of the extreme importance of Sir Frank Heath's report, the Institute takes the liberty of offering its services in any direction in which it can be of service."

Extracts of the report as affecting the New Zealand Institute were sent to incorporated societies and to the Press. On the 3rd September the Scientific and Industrial Research Bill came before the meeting, and it was resolved: "That the New Zealand Institute hopes that Sir Frank Heath's recommendation that the appointments to the Council of Scientific and Industrial Research should be made by the Prime Minister after consultation with the governing body of the New Zealand Institute will be given effect to." This resolution was forwarded by the Internal Affairs Department to the Secretary of the Department of Scientific and Industrial Research, but no action resulted.

*Australasian Association for the Advancement of Science.*—Invitations were received from the A.A.A.S. to the 1926 Congress at Perth and Adelaide, and at a meeting of the Standing Committee on the 8th July the following resolution was passed:—"That in the opinion of the Institute great advantage would result to the scientific departments throughout the Dominion through representation of the departments at the A.A.A.S. meeting at Perth by scientific heads. The Institute, however, considers the importance of this less than that of the Pan-Pacific Science Congress." The Under-Secretary replied that Mr. Malcolm Fraser, Government Statistician, would represent the Government at the A.A.A.S. meeting. The Institute did not send any delegates.

*Carter Bequest.*—At a meeting of the Standing Committee held on the 19th February, it was moved that a meeting be arranged between the Standing Committee and the City Observatory Committee to consider the latter's proposals regarding the Carter Bequest. This meeting was held on the 2nd November, and was attended by Councillor Meadowcroft, Dr. Adams, and Councillor Huggins, and members of the Standing Committee. The proposals which were submitted by the Committee to the last Annual Meeting formed the basis of the discussion, and finally it was resolved that a small committee consisting of Dr. Adams (Convener), Professor Kirk, and Councillor Huggins, be set up to confer on the matter and to report to the Annual Meeting.

*Board of Agricultural College.*—On the 3rd September it was resolved that Mr. M. A. Elliott be recommended as a member of the Board of the new Agricultural College. This resolution was forwarded to the Hon. Minister for Agriculture.

*New Zealand Institute Representative.*—Mr. H. D. Skinner, who was awarded the Rockefeller Scholarship for Anthropology, and who was leaving for America, was appointed to represent the Institute at any meetings of the American Association for the Advancement of Science, and at any other scientific meetings he may attend while in America.

*Signatures of Cheques.*—On the 3rd September Professor H. B. Kirk was authorised to sign cheques, etc., in conjunction with the President or Hon. Treasurer.

## BUSINESS ARISING FROM REPORT OF STANDING COMMITTEE.

1. *Cost of Printing Transactions.*—Professor Kirk moved and Professor Farr seconded, “ That a committee consisting of the Hon. G. M. Thomson, Professor Worley, Professor Farr, be appointed to report before the end of the meeting on the cost of printing the Transactions in past years.”

2. *Financial Year.*—On the motion of Professor Worley it was resolved that the incorporated societies be asked to make the end of their financial year 31st October. (This automatically rescinds a previous resolution that incorporated societies should end their year on 31st December).

3. *Uppsala University.*—Dr. Cockayne suggested that as full a set of the Transactions as possible be sent to Uppsala University.

4. *Hon. Editor.*—Mr. Hill moved, and it was carried, that the Hon. Editor be asked to attend the afternoon's meeting.

5. *Representation on Tongariro National Park Board.*—After some discussion, and on its being pointed out that the term of office of President of the Institute was for only two years, Professor Kirk moved and Mr. Hudson seconded, “ That the Minister of Lands be reminded that it is the opinion of the Institute that it would make for efficiency if it could elect its representative on the Tongariro National Park Board instead of its being represented by its President ex officio. (This course had been recommended by the President in his presidential address.)

6. *Scenic Reserves.*—Dr. Cockayne moved that Adams Island\* and Disappointment Island in the Auckland Islands, be made scenic reserves.

The report of the Standing Committee was then adopted.

*Hon. Treasurer's Report and Balance Sheet.*—Mr. M. A. Elliott, Hon. Treasurer, presented his report, and the statements following, which had been duly audited by the Auditor-General:—

### HONORARY TREASURER'S REPORT FOR THE YEAR ENDING 31ST DECEMBER, 1926.

The balance-sheet for the year ending 31st December, 1926, shows a debit balance of £163/19/., as compared with a credit balance of £263/13/8 on 31st December, 1925. This, however, was in a measure anticipated as mentioned in my previous report, and is owing to the liability for Volume 56 to the Government Printer, amounting to no less than £1610, being brought into this year's accounts.

Since the last Annual Meeting of the Institute, satisfactory arrangements have been made with a private firm of printers who have contracted

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\*It was since learned that Adams Island is already under the Land Act a reserve for the preservation of native flora and fauna.

to print the annual volume of Transactions at a very considerable reduction in cost. The consent of the Minister of Internal Affairs has been obtained to this arrangement, and also to the balance due to the Government Printer amounting to £1545, being liquidated in annual instalments spread over four years. It is anticipated, however, that this liability will be extinguished within three years provided that the Statutory grant remains at £1500. It should not be long, therefore, before our financial position will be in a very much sounder position than has been the case for many years.

The Trust Accounts continue in a satisfactory condition. The Carter Bequest capital now stands at £6404, showing an increase of £349 for the year. Funds as they accrue in this and other accounts, are being re-invested in 5 per cent. Post Office Inscribed Stock, due 1929, bought at £96/12/6 to £98. Post Office Inscribed Stock for £400 purchased in 1922 for £388/8/4 on account of the Carter Bequest and Hector and Hutton Memorial Funds will mature during the year (1927) and it will be necessary to select a suitable re-investment.

The books and accounts have, as customarily, been well and accurately kept by the Assistant Secretary.

M. A. ELLIOTT.  
Honorary Treasurer.

NEW ZEALAND INSTITUTE.—STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE  
YEAR ENDING 31ST DECEMBER, 1926.

*Receipts.*

	£	s.	d.
Balance as at 31st December, 1925 .....	1,737	18	1
Statutory Grant .....	1,500	0	0
Levy, Volume 56, Incorporated Societies .....	209	10	0
Publications Sold .....	44	14	7
Authors' Reprints .....	62	1	7
Research Grant from Internal Affairs .....	716	7	9
Research Grants Refunded by Grantees .....	27	14	4
Interest at P.O.S.B. ....	48	17	8
Endowment Fund—Interest on Investment .....	18	13	1
Carter Bequest—Interest on Investment .....	359	16	2
Carter Bequest—Books Sold .....	12	5	2
Carter Library Legacy—Interest .....	6	2	6
Hector Memorial Fund—Interest .....	68	10	0
Hutton Memorial Fund—Interest .....	62	3	1
Hamilton Memorial Fund Transfer to Bank of N.Z. ....	1	3	11
Hutton Memorial Fund Transfer to Bank of N.Z. ....	39	12	1

£1,915 10 0

*Expenditure.*

	£	s.	d.
Government Printer .....	1,100	0	0
Binding Books in Library .....	12	13	9
Travelling Expenses .....	97	12	6
Salary .....	300	0	0
Charges (Insurance, Bank Com., etc.) .....	7	0	2
Petty Cash (Postages, etc.) .....	19	8	2
Stationery (C. M. Banks) .....	1	6	3
Volumes 2 and 3 purchased at auction) .....	4	2	0
Research Grants .....	737	12	11
Hector Prize .....	45	0	0
Hamilton Prize .....	1	0	0
Carter Bequest Interest Re-invested .....	349	11	2
Hutton Memorial Fund Interest Re-invested .....	100	0	2
Trust Funds Transferred to Accounts .....	27	18	1
Balance as Under .....	2,112	4	10
	<hr/>		
	£4,915	10	0
	<hr/>		

	£	s.	d.	£	s.	d.
Balance in Bank of New Zealand .....	699	5	4			
Less Unpresented Cheques .....	466	1	8			
	<hr/>			233	3	8
Balance in P.O.S. Bank .....				1,871	0	8
Petty Cash in Hand .....				8	0	6
	<hr/>			£2,112	4	10
	<hr/>					

Made up as follows:—

	Dr.	Cr.
	£ s. d.	£ s. d.
Library Fund .....		176 19 4
Government Research Grants .....		555 7 1
Endowment Fund Revenue Account .....		66 10 8
Carter Bequest Books Sold .....		12 5 2
Government Printer .....		1,545 9 9
Outstanding Accounts .....	80 8 2	
Institute Working Account .....	163 19 0	
Balance as at 31st December, 1926 .....	2,112 4 10	
	<hr/>	
	£2,356 12 0	£2,356 12 0
	<hr/>	

NEW ZEALAND INSTITUTE.—STATEMENT OF ASSETS AND LIABILITIES AS AT  
31ST DECEMBER, 1926.

*Liabilities.*

	£	s.	d.
Carter Bequest Capital Account .....	6,404	12	6
Hector Memorial Fund Capital Account .....	1,184	18	1
Hutton Memorial Fund Capital Account .....	1,214	6	0
Hamilton Memorial Fund Capital Account .....	48	7	11
Carter Library Legacy Capital Account .....	100	0	0
Endowment Fund Capital Account .....	397	17	0
Carter Bequest Revenue Account .....	56	1	11
Hector Memorial Fund Revenue Account .....	20	10	4
Hutton Memorial Fund Revenue Account .....	6	12	9
Hamilton Memorial Fund Revenue Account .....	4	11	7
Carter Library Legacy Revenue Account .....	9	3	6
Endowment Fund Revenue Account .....	66	10	8
Library Fund .....	176	19	4
Government Printer .....	1,545	9	9
Government Research Grants .....	555	7	1
	<u>£11,791</u>	<u>8</u>	<u>5</u>

*Assets.*

	£	s.	d.	£	s.	d.
Inscribed Stock .....				7,568	2	11
P.O. Inscribed Stock .....				1,733	10	8
Cash in P.O.S.B. ....				1,871	0	8
Cash in Bank of N.Z. ....	699	5	4			
Unpresented Cheques .....	466	1	8			
				<u>233</u>	<u>3</u>	<u>8</u>
Petty Cash in Hand .....				8	0	6
Outstanding Accounts .....				80	8	2
Carter Bequest P.O.S.B. Account .....				43	16	9
Hector Memorial Fund P.O.S.B. Account .....				20	10	4
Hutton Memorial Fund P.O.S.B. Account .....				6	12	9
Hamilton Memorial Fund P.O.S.B. Account .....				52	19	6
Carter Legacy P.O.S.B. Account .....				9	3	6
Balance of Liabilities over Assets .....				163	19	0
				<u>£11,791</u>	<u>8</u>	<u>5</u>
To Balance .....	£163	19	0			

Examined and found correct.—G. F. C. CAMPBELL, Controller and Auditor-General.

NEW ZEALAND INSTITUTE.—RESEARCH GRANTS FOR THE YEAR ENDING  
31ST DECEMBER, 1926.

							£	s.	d.
February	24	To	Dr.				25	0	0
		"	Mr. Tonnoir				37	10	0
		"	Mr. Powell				3	2	6
		"	Mr. Knapp				6	4	3
March	5	"	Dr. Farr				10	7	2
	26	"	Dr. Denham				30	0	0
		"	Mr. Falla				21	0	2
		"	Mr. Finlay				24	11	5
		"	Dr. Farr				14	13	5
		"	Mr. Laing				23	4	9
		"	Dr. Malcolm				8	10	0
		"	Mr. Powell				85	0	0
		"	Mr. Short				2	12	6
		"	Mr. Wild				25	0	0
April	7	"	Mr. Tonnoir				10	0	0
May	21	"	Mr. Short				16	19	4
July	16	"	Mr. Finlay				15	0	0
		"	Dr. Malcolm				5	0	0
		"	Mr. Archey				8	6	8
September	9	"	Mr. Laing				5	0	0
		"	Dr. Allan				30	0	0
		"	Dr. Chilton				20	0	0
		"	Dr. Allan				35	0	0
		"	Mr. Archey				5	0	0
September	21	"	Mr. Skey				50	0	0
		"	Dr. Hilgendorf				20	0	0
		"	Mr. Short				60	0	0
		"	Mr. McDowell				6	0	8
November	9	"	Mr. Skey				10	0	0
		"	Dr. Inglis				23	8	11
		"	Dr. Farr				20	0	0
		"	Mr. Falla				30	0	0
		"	Mr. Short				20	0	0
December	13	"	Professor Worley				3	0	0
		"	Mr. Skey				5	1	6
		"	Mr. Knapp				30	0	0
		"	Dr. Chilton				6	4	5
		"	Mr. Jobberns				33	15	1
		"	Dr. Malcolm				8	0	2
December	17	"	Mr. Laing				555	7	1
		"	Balance						

£1,353 0 0

			Cr.		£	s.	d.
January	1	By	Balance	.....	548	17	11
February	22	"	Refund	.....	1	3	7
March	5	"	Treasury	.....	50	0	0
		"	"	.....	50	0	0
April	1	"	"	.....	25	0	0
		"	"	.....	3	2	6
		"	"	.....	24	11	5
		"	"	.....	85	0	0
		"	"	.....	30	0	0
June	17	"	Refund	.....	26	10	9
August	27	"	Treasury	.....	30	0	0
		"	"	.....	35	0	0
		"	"	.....	30	0	0
		"	"	.....	20	0	0
		"	"	.....	8	6	8
October	19	"	"	.....	40	0	0
		"	"	.....	50	0	0
		"	"	.....	15	0	0
		"	"	.....	50	0	0
		"	"	.....	15	0	0
		"	"	.....	60	0	0
December	23	"	"	.....	30	0	0
		"	"	.....	25	0	0
		"	"	.....	10	0	0
		"	"	.....	30	0	0
		"	"	.....	10	0	0
		"	"	.....	40	0	0
April	1	"	"	.....	10	7	2
					£1,353	0	0
By Balance .....					£555	7	1

## NEW ZEALAND INSTITUTE.—TRUST ACCOUNTS.

*Carter Bequest Revenue Account for the Year ending 31st December, 1926.*

Dr.			Cr.		£	s.	d.
To	Interest Invested in	£ s. d.	By	Balance	31	0	4
	P.O. Inscribed Stock	349 11 2		Interest	359	16	2
	Balance	56 1 11		Interest P.O.S.B.	2	11	5
		£405 13 1		Books Sold	12	5	2
					£405	13	1
By Balance .....					£56	1	11

*Hector Memorial Fund Revenue Account for the Year ending 31st December, 1926.*

Dr.			Cr.		£	s.	d.
To	Balance	£ s. d.	By	Interest	68	10	0
	Prize (Mr. Skinner)	45 0 0		Interest P.O.S.B.	12	0	0
	Balance	20 10 4					
		£69 2 0			£69	2	0
By Balance .....					£20	10	4

*Hutton Memorial Fund Revenue Account for the Year ending 31st  
December, 1926.*

Dr.			Cr.		
	£	s. d.		£	s. d.
To Interest Invested .....	100	0 2	By Balance .....	41	0 3
Balance .....	6	12 9	Interest .....	62	3 1
			Interest P.O.S.B. ....	3	9 7
	<u>£106</u>	<u>12 11</u>		<u>£106</u>	<u>12 11</u>
			By Balance .....	£6	12 9

*Hamilton Memorial Fund Revenue Account for the Year ending 31st  
December, 1926.*

Dr.			Cr.		
	£	s. d.		£	s. d.
To Prize (Marwick and Finlay) .....	1	0 0	By Balance .....	3	14 7
Balance .....	4	11 7	Interest .....	1	8 2
	<u>£5</u>	<u>11 7</u>	Interest P.O.S.B. ....	8	10
				<u>£5</u>	<u>11 7</u>
			By Balance .....	£4	11 7

*Carter Library Legacy Revenue Account for the Year ending 31st  
December, 1926.*

Dr.	Cr.
	£ s. d.
	By Balance .....
	Interest—Public Trustee .....
	Interest .....
	Interest P.O.S.B. ....
	Balance .....
	<u>£9</u> <u>3 6</u>

The report was adopted.

*Overdue Accounts.*—It was moved by Mr. Elliott, seconded by Professor Kirk, "That a surcharge of 20 per cent. be made on all accounts issued by the Institute, this charge to be remitted to all who pay the accounts within two months.

*Manawatu Philosophical Society.*—Mr. Elliott made a statement in regard to the position of this society, and anticipated greater prosperity in the future.

*Carter Bequest.*—A letter was received from Dr. Adams, convener of the joint committee of the Institute and the Observatory Committee set up by the Standing Committee on the 2nd November, 1926, as follows:—

The President,  
New Zealand Institute,  
Wellington.

The preliminary question is as to whether the City Telescope is adequate as a Carter Memorial Telescope. The Committee is of opinion that it is. None the less, a few years' experience with this telescope might show that

a larger telescope could be efficiently used in the neighbourhood of Wellington, and the accumulating Carter Fund might then be in a position to furnish such a telescope. The joint Carter Committee in 1921 had this in view in proposing that a dome should be built suitable for a larger telescope. If it is agreed that the telescope is adequate, then two possible courses seem to be open:—

(1) A course already proposed by the Institute, namely, that the City Council should hand over the City Telescope as a Carter Telescope, and to give a site, the Institute giving from the Carter Fund £2,500 to £3,000 to build an Observatory. Under this proposal the Observatory would be administered by the Carter Observatory Committee, appointed in part by the City Council, and in part by the Institute. To this plan the City Council demurs, unless the City Council representatives are conjointly with the Institute, trustees of the Observatory.

(2) That the Institute, as Carter Trustees, should buy the City Telescope at the price paid by the City Council, the Council giving the site, and the Institute as Carter Trustees, managing the Observatory.

C. E. ADAMS,  
Convener.

25th January, 1927.

Professor Kirk moved and Professor Segar seconded, "That the second plan in the above report be adopted." Professor Farr moved and Professor Park seconded, "That consideration of the motion be deferred until the afternoon." This motion was carried.

Subsequently it was moved by Mr. Elliott and seconded by Mr. Hill and carried, "That provided (1) the Board is assured by adequate legal opinion that the course proposed is in accordance with the provisions of the trust; (2) that the amount to be expended by the Carter Bequest shall not exceed £500 for the telescope and £3000 for the building; (3) that full and proper provision be made by the New Zealand Astronomical Society or other responsible body for the upkeep and work of the Observatory and that the Carter Bequest shall not be called upon in any way to provide for this, the proposal 2 of the joint committee be adopted, and that in terms thereof an agreement with the Wellington City Council be finalised."

## RESEARCH GRANT REPORT.

### REPORT OF RESEARCH GRANT COMMITTEE.

The Committee reports that for the unallotted balance of the Research Grant for 1925 applications were invited early in the year and five were received for a total amount of £170. Of these the Committee recommended that grants be made in four cases to the amount of £155.

For grants from the amount voted in 1926, eleven applications for new grants of a total amount of £960 were received, and one for the transfer of a grant already made.

The Committee approved of the transfer and recommended grants in six cases to the amount of £525. One application has not yet been decided upon pending further information from the applicant. In the remaining four cases the Committee was unable to recommend the grants asked for.

Reports or interim reports have been received from those holding grants and abstracts of these, kindly prepared by the Assistant Secretary, are appended. From these it will be seen that in one or two cases little or no progress has been made for reasons stated, but in the large majority of cases good work has been done and satisfactory results attained.

The Committee is of opinion that the research grants made through the New Zealand Institute have produced very satisfactory results, and have led to the prosecution of many lines of scientific investigation that would not have been undertaken otherwise.

CHAS. CHILTON,  
Chairman.

## RESEARCH GRANTS.

REPORT FOR THE YEAR ENDING 31ST DECEMBER, 1926.

Dr. H. H. Allan, was, in 1924, granted £50 for research on Mt. Egmont Forest. He reports that a general study of the forest on the south-east, the east, and the north-east areas, and portion of the Pouahi Range has been made, and a preliminary examination of the forest on the western side. Herbarium and garden material for the elucidation of certain problems has been secured. Reports are in preparation on the general ecology of the forest and its various associations, and on the epiphytic, bryophytic, and lichen content, and their significance to silviculture. It is hoped to complete the work by the end of 1927. Expenditure for the year amounts to £13/18/6.

Dr. H. H. Allan was, in 1923, granted £30 for research on cocksfoot and ryegrass. He reports that work has been hampered by the season, a large portion of the area devoted to ryegrass being flooded, and much had to be restarted in another locality. Work has been continued along the lines of previous reports, and a good deal of work on the germination of various strains has been accomplished, and from the germination work a great number of individual plants have been secured for further study. From the nature of the work only preliminary accounts can be published for some time to come, but no further grant will be necessary. Expenditure for the year amounts to £4.

Mr. G. Archey was, in April, 1926, granted £40 for the study of new species of New Zealand Centipedes and Millipedes. He reports that a microscope has been purchased and the work is now proceeding, but no paper is yet ready for publication. The expenditure to date has been £32/0/8.

Mr. G. Brittin was, in 1919, granted £100 for research on fruit-tree diseases. He reports that the experiments of manuring with blue lupin, followed by lime, have proved most satisfactory. A comparison between the trees thus manured and those not treated showed that the former showed more growth, that the fruit-buds were stronger and more evenly spaced, and were less affected by bud-dropping, proving that by keeping the trees in strong growth they were more able to resist disease. The usual routine work of pruning and spraying was again carried out, and the results have proved satisfactory, brown rot being practically non-existent. Expenditure for the year amounts to £4/19/1.

Dr. Chilton was, in December, 1925, granted £100 to supervise a research of the food-supply of marine fishes to be carried out by Mr. E. W. Bennett, M.Sc. He reports that the work has been carried on without a break, an average of 20 hours per week being devoted to the research (exclusive of evening work and related studies). It was found at the outset that before quantitative, seasonal, and other such studies could be undertaken, it was necessary to know precisely what species of food-providing organisms occur in New Zealand, and that for a start specialisation in one group would be essential; attention has, therefore, been so far confined to the most important group, the Copepoda (exclusive of parasitic species). It was found that the New Zealand species of this group had been only very imperfectly studied. With the assistance of the Hon. G. M. Thomson, Mr. Maxwell Young and Professor Speight, an extensive collection of papers and works dealing with the Copepoda, has been brought together, and a catalogue of all known species in New Zealand has been drawn up on the lines of Hutton's "*Index Faunae Novae Zealandiae*." This list with a bibliography and historical account has been read before the Philosophical Institute of Canterbury under the title, "*A List of Free-swimming Copepoda of New Zealand*." Observations have also been made on the fresh-water Copepoda, and a paper read on the "*Biology of the Calanoid *Boeckella triarticulata**." Extensive collections have been made and are stored in the Biological Laboratory of Canterbury College. Expenditure so far amounts to £34/0/3.

Dr. K. M. Curtis was, in 1920, granted £100 for research in parasitic mycology. She reports that the research work on the brown rot of stone-fruit was completed last year, and the results were placed before the Science Congress in Dunedin. The paper is now in the Press. The whole of the grant except 4/8 was expended, chiefly in books.

Mr. W. C. Davies was, in 1921, granted £50 for research in soil bacteria and protozoa. He reports that investigations have been carried out during the year chiefly concerning the correlation of the bacterial counts with the relative fertility of a number of soils in the Nelson district. A paper dealing with one aspect of the work will shortly be forwarded to the Journal of Science and Technology. The whole of the grant is expended.

Professor H. G. Denham was, in 1925, granted £115 for research on the Low-temperature Carbonisation of Brown Coals. He reports that the investigation has not yet started, but arrangements have been made with a graduate to begin work on the subject in February. Expenditure amounts to £10/7/2.

Professor T. H. Easterfield was, in 1921, granted £200, and in 1926 an additional £100 for research on the cool storage of fruit. He reports that the work has followed closely on the lines of the previous year, and has definitely shown that the trouble commonly known as internal breakdown or flesh collapse is primarily due to low temperature, but that a moist atmosphere greatly increases the intensity of the trouble. The work has extended to varieties of apples not experimented with in previous seasons. The results of the investigation have been published in a Bulletin of the Cawthron Institute. Expenditure amounts to £216/1/4.

Professor C. C. Farr was, in 1921, granted £15 for research on the physical properties of gas-free sulphur. He reports that work has proceeded as far as time and opportunities have permitted. It is believed that a sample of sulphur freer from gaseous impurities than any previous sample has been prepared, and its properties are now under examination. It is, however, hoped to improve still more. The expenditure to date has been £10 1/11.

Professor C. C. Farr was, in 1924, granted £250 for research on the occurrence of Helium in New Zealand. He reports that during the year work has been carried on actively. Many samples of gas which had been previously collected have been examined, and the existence of helium in all the samples has been proved. In this way the apparatus has been tested and some minor alterations which have suggested themselves have now been made. A new air compressor has been installed at Canterbury College which supplies an abundance of liquid air in a reasonable time, and this has greatly facilitated the carrying on of the work. The expenditure incurred to date is £118/4/9.

Mr. H. J. Findlay, in 1923, was granted £100 for research on tertiary mollusca. He reports that the report on the Mollusca gathered by the members of the Chatham Island Expedition has been forwarded to the Editor of the Transactions for publication. He is still at work on the Turridae, but lacks sufficient Australian material. Most of the year's work has been put into an extensive thesis dealing with the whole of the New Zealand Molluscan Fauna, both Tertiary and Recent, and entitled, "A Further Commentary of New Zealand Molluscan Systematics." This has gone forward as a thesis for his D.Sc. Degree. Two more papers will appear in the Transactions. The whole of the grant has been expended.

Mr. F. W. Foster, in 1923, was granted £25 for collating the notes, etc., of the late Sir David Hutchins. He reports that he is still engaged on the Section on the Exotic Trees and Plantations, and has incurred no expenditure.

Dr. F. W. Hilgendorf, in April, 1926, was granted £50 for co-ordinating agricultural experiments. He reports that the amount of the grant was expended in the purchase of a calculating machine for calculating the results of manurial experiments. The machine arrived from America in September and work has been commenced.

Mr. H. Hill, in 1925, was granted £50 for completing a survey of the Taupo Plains to test the prospects of artesian water supply. He has forwarded a comprehensive report accompanied by maps and sketches. His expenditure for the year has been £23/2/-. He has consulted a very capable artesian well-sinker who has studied and tested his Heretaunga artesian well-system, and his opinion is that £100 would enable complete tests to be made for water in places indicated by Mr. Hill.

Dr. Inglis was, in 1923-25 granted £55 for research on essential oils of native plants. He reports that the programme of work carried out during

the year includes that on black pine and pepper plant, *Dacrydium biforme*, *Metrosideros* silver pine, white pine and totara. A paper has been prepared on *Dacrydium biforme* and should be ready for publication next year. It has been difficult to obtain proper supplies of black pine leaves, and the investigations on this and on the pepper plant are being continued next year. Expenditure amounts to £16/7/7.

Mr. G. Jobberns was, in April, 1926, granted £50 for correlation of shore-platforms of the north-east coast of the South Island. He reports that field-work has been done as far north as Stonyhurst. A paper on the Motonau Plain was read before the Philosophical Institute of Canterbury, but publication is being withheld pending investigation of the coast further north, this being necessary before any accurate correlations can be made. It is hoped to get most of the work on the Marlborough section of the coast completed early in 1927. Expenditure during the year amounts to £6/4/5.

Mr. F. V. Knapp, in 1925, was granted £25 for collecting Maori Artifacts. He reports that at the northern end of Fisherman's Island in the estuary of the Waimea River he has discovered a number of interesting and rare implements used by the canoe-workers in their building operations. He had hoped to locate a canoe slip, but so far has not been successful. Expenditure amounts to £8/4/6.

Mr. R. M. Laing, in 1924, was granted £100 for research on New Zealand Algae. He reports that during 1925 he studied the literature published in respect to New Zealand Algae, and as a result he published a paper to appear in Volume 57 of the Transactions. This year he has been engaged in adding to and classifying his collection, and certain specimens have been sent to Sweden and to Kew for description and identification. He has written a paper on the External Distribution and Relationships of the New Zealand Seaweeds, and this is to be published in the Transactions. He has had some correspondence during the year regarding the commercial use of seaweeds, but so far nothing definite has resulted. The Japanese trade was, in 1914, in seaweeds, particularly, *Porphyra*, valued at annual rate of £800,000. Expenditure to date amounts to £51/17/1.

Dr. J. Malcolm, in 1918, was granted £30 for research on the Pharmacology of New Zealand Plants. He reports that during 1926, owing to the pressure of other work, nothing could be done on this research, but he is still hopeful that it may be used when the new pharmacological department of the new medical school is in working order. He is prepared to refund the unexpended portion, namely £10, if desired.

Dr. Malcolm, from 1918-26 has been granted £631/3/7 for research on the food-value of New Zealand Fishes. He reports that vitamin experiment tests have been made on the application of recently-published methods and valuable results were reached. Two new samples of mutton-bird oil were examined by rat experiments, and the presence of vitamin A in this oil was confirmed. Also fresh Stewart Island oysters, examined in mid-winter, proved to be rich in this.

Dr. E. Marsden, in 1924, was granted £60 for seismological research. He reports that as yet no work has been done on this question, but Professor Farr is making enquiry in Japan as to a local earthquake recorder. It was hoped that work could be carried out with the Eotvos Torsion Balance in the direction of a gravity survey, but unfortunately it was found that a much larger sum would be required. No expenditure has been incurred.

Mr. F. H. McDowall, in 1924, was granted £60, and in 1926 an additional £20, for investigation of the Ngaio Oil. He reports from London where he is continuing the research in the London University that he has a paper almost ready for publication, and it is to be submitted to the Chemical Society in the near future. He has forwarded a summarised account of the results so far obtained, some of which were published in the Journal of the Chemical Society, 1925. Expenditure to date amounts to £58/8/11.

Mr. W. J. Phillips, in 1924, was granted £30 for research on the life-histories of New Zealand Fishes. He reports that during the year he has visited West Oxford, Lake Forsyth, and River Styx in North Canterbury. A special visit has been made to Masterton and Pahiatua. Three papers were published during 1926, one in the Transactions on *Galaxias burrowsius* Phil-

lipps, one in *Nature* on Fresh Water Fishes of New Zealand, and additional notes on these were published in the *New Zealand Journal of Science and Technology*. Other articles are in course of preparation. Expenditure to date is £20/13/-.

Mr. A. W. B. Powell, in 1925, was granted £50 for a survey of the molluscan fauna of Manakau Harbour. He reports that the microscope purchased with portion of the grant has been of great assistance in the sorting of marine dredgings. Two papers have been compiled during the present year since receipt of equipment. One entitled, "Mollusca from 100 fath. off Lyttelton with descriptions of four new species, and also a Pliocene Fossil" was published on 22nd October in the *Records of the Canterbury Museum*. A second paper on Mollusca from 23 fath. off Ahipara will be published in Volume 58 *Transactions New Zealand Institute*. Much preliminary sorting of other material has also been accomplished and results will be forthcoming next year. Expenditure amounts to £37/12/7.

Research Committee, Auckland, was in 1925, granted £65 for an ecological survey of the Waitemata Harbour. Mr. Falla, Hon. Secretary, reports that the committee consists of Miss Crookes, Messrs. Archey, Falla, Griffen, Powell and Graham. Its aims are (a) to list and classify the existing flora and fauna of the area which has been tentatively fixed as extending from Riverhead to Ponui Island at the eastern entrance of the harbour, Motuhi at the north-east and Rangitoto Beacon at the north; (b) to determine as far as possible the seasonal changes in the life of the area, and the relationship of one form to another.

The fisheries branch of the Marine Department has sanctioned the taking of specimens of fish at any stage of development, and the material collected should provide useful data regarding the distribution of food fishes. The Committee forwarded to the Standing Committee of the Institute a report on the question of the economic value of cormorants. The expenditure to date is £30/2/6.

Mr. H. F. Skey, during the year, took over the research on Upper Air, which had been commenced by Captain Isitt, who had been transferred to England. The balance of the grant then was £36/10/9. Mr. Skey reports that since July 25 flights have been observed in the Christchurch Domain and the results have been worked out, plots and velocities graphed, and from 22 of the flights the average results have been tabulated, and he forwards a copy of the table and graphs. Bad weather has interfered with the observations, but he expects to get a better summer series. Expenditure to date is £15/15/. The Department of Scientific and Industrial Research has asked permission to borrow apparatus used in this research during February for observations at Sockburn, and this has been granted.

Mr. W. F. Short was, in 1925, granted £100, and in 1926 an additional £75, for a research on the constitution of New Zealand Essential Oils. He reports that all the essential apparatus has not yet come to hand and work has been confined to general preparation for the research, and more especially to micro-analysis. He expresses his gratitude to the Institute for its generous assistance in making such a research possible. Expenditure to date is £95/19/1.

Mr. A. L. Tonnoir was, in 1925, granted £50 for a research on Glow-worms. He reports that observations were made at Waitomo Caves, Nehotupu, Port Waikato, and then again at Waitomo, where 450 worms were collected and brought alive to Christchurch, where they were placed in an underground chamber which had been specially built for the purpose in the Canterbury Museum ground. The specimens placed in the tunnel did not survive long, probably on account of some noxious substance contained in the concrete roof. The roof was, therefore, partly replaced by frames supporting grass sods and some niches were excavated on the sides of the entrance pit. Several further lots of worms got acclimatised to the modified tunnel. Mr. Tonnoir regrets that, owing to his appointment as Field Entomologist at Cawthron Institute, he had to suspend operations in the meantime, but hopes next spring to resume work. He is sorry that the tunnel which was built and which absorbed a great part of the grant, will now be useless to him and he will probably have to apply for a further grant to erect one in Nelson. Total expenditure is £43/8/9.

Professor F. P. Worley was, in 1923, granted £25, and in 1925 an additional £25, for research on the chemistry of essential oils and other products of the New Zealand flora. He reports that he has now a student available to work on *Melicope ternata*, and during January he will be collecting material for this. The expenditure to date is £19/7/-.

Professor W. N. Benson was granted, in 1925, £50 for preparing rock sections of the Dunedin region. He reports that rock-microslides are being made at a cost of from £20-£25, and more will be required later on. So far none of the grant has been expended, but the whole of it will be required soon.

The following grantees have not forwarded a report of their work:—

Dr. Adams, granted £200 for research on Southern Stars.

Dr. Farr, £30, for Radium Emanation and Goitre.

Mr. H. Hamilton, £30, for research on Cave Fauna.

Mr. E. K. Lomas, £25, for research on Intelligence of School Children.

Professor Sperrin-Johnson, £100, for Mosquito-Control.

Dr. J. A. Thomson, £100, research on Chemical Character of Igneous Rocks.

Messrs. Wild and Tankersley, £25, for Soil Survey in the Manawatu District.

On the motion of Dr. Chilton, seconded by Mr. Wright, the report was adopted.

### LIBRARY COMMITTEE'S REPORT.

The Library Committee begs to submit its report for 1926.

Eleven new exchanges were recommended, mostly in the fields of Biology and Geology. The list is given in the Institute's Annual Report. The binding of periodicals is proceeding as far as funds permit, and it was recommended specially to proceed with the Transactions of the Australian Royal Societies the Royal Society of Edinburgh, the Linnean Society, the Geological Survey of India, and the U.S. Journal of Agricultural Research. Missing numbers of sets are being applied for. The Committee would stress the importance of prompt application for the replacement of missing numbers as lapse of time renders this much more difficult, and also holds up the binding.

The Bombay Natural History Society, which has received our Transactions regularly has failed to reciprocate since 1895, and now pleads that it cannot afford to exchange. They have been requested to send what they can in exchange for what they have already received.

It was recommended to present a partial set of the Transactions, so far as they are available, to the Wellington Training College.

In response to a circular issued by the Assistant Secretary relating to the lending of periodicals to members interested in special subjects, some encouraging replies have been received, which should lead to fuller use being made of the valuable library which the Institute now possesses.

The library accommodation, which has been greatly extended, is now no more than adequate, the provision for the future continues to cause anxiety. The proposal of the Department of Scientific and Industrial Research for a central scientific library, of which the Institute's library would form a nucleus, is a doubtful one which will require serious consideration in the near future.

The Committee stresses the importance of proceeding without delay with the publication of Mr. Archey's Catalogue of Scientific Periodicals. This important work, which has so long been looked forward to will be of immense value to all research workers in New Zealand.

D. M. Y. SOMMERVILLE,

Hon. Librarian.

19th January, 1927.

On the motion of Dr. Thomson, seconded by Dr. Chilton, the report was adopted.

## GREAT BARRIER REEF COMMITTEE'S REPORT.

Six meetings of the Committee were held during the past year.

*Death of Scientific Director.*—During the past year the Committee has suffered a severe loss by the death of Mr. Charles Hedley, the Scientific Director. Mr. Hedley was in Sydney making arrangements to attend the Pan-Pacific Science Congress in Japan. He was in his usual state of good health, but contracted an illness which resulted in heart failure from which he died on 13th September last.

*New Members of Committee.*—Dr. P. S. Clarke, Captain J. A. Edgell, and Mr. T. L. Jones, have been appointed members of the Committee.

*Boring Operations.*—The Victorian Government provided a complete Calyx-boring plant, also a plant for shallow boring. In April, 1926, the plant was transferred from Cairns to Oyster Cay. A large hut was erected on the island and tanks and water shipped over. The work of erecting the plant and boring were carried out by the Goldfields Diamond Drilling Co.

Boring was commenced on May 6th, and work was carried on for four months during which time casing from 7 inches to 5 inches was forced down to 580 feet, and boring rods probed a further 20 feet. As the Committee did not have sufficient funds to meet further operations with 4 inch casing it was decided to cease work, withdraw the casing and remove the plant. Accordingly the plant was transferred to Melbourne in September. Coralline material extended from the surface to 427 feet, when a quartz sand loosely aggregated was encountered. No coralline material appeared in the quartz sand which was of a greenish colour due to glauconite or greenolite. The sand extended to 600 feet without change. The old rocks had not been reached.

*Investigations.*—Mr. F. Jardine carried out topographical and geological investigations on the coastal area extending from Townsville to the Burdekin River. He concluded that the marine deposits had not been elevated more than 20 feet.

Mr. P. C. Morrison furnished a report on the Barrier Reef Plankton Collections. Mr. G. Stanley is preparing papers on the geology and physiology of the Whitsunday Islands and adjacent coast.

*Biological Expedition.*—The committee decided to spend a sum not exceeding £1,000 on a biological expedition to investigate the ecology of a coral cay, co-operating with a party of three or four from England which expects to raise a further £500. Two or three Australian Zoologists would accompany the party which would operate for a year. The Low Isles were suggested as a base.

*Financial Statement.*—This was submitted to the Committee on the 30th September, 1926.

				£	s.	d.
Receipts	....	....	....	4471	17	11
Expenditure	....	....	....	3937	7	10
Balance in Hand	.....	.....	.....	£534	10	1

W. R. B. OLIVER,

N.Z. Institute Representative on the Committee.

On the motion of the Hon. G. M. Thomson, seconded by Mr. Elliott, the report was adopted. Dr. Thomson moved and it was carried, "That Mr. Oliver be reappointed representative on this Committee."

## PAN-PACIFIC SCIENCE CONGRESS REPORT.

On the motion of Dr. Thomson, seconded by Mr. G. V. Hudson, it was resolved that a vote of thanks be accorded to Dr. Farr for his full and able report on the Pan-Pacific Science Congress, 1926.

On the motion of Mr. Hill, seconded by Mr. Hudson, it was resolved that the report be published in the Proceedings of the New Zealand Institute.

## REPORT ON A VISIT TO JAPAN

AS DELEGATE FROM THE NEW ZEALAND INSTITUTE TO THE THIRD PAN-PACIFIC  
CONFERENCE, OCTOBER-NOVEMBER, 1926.

(By C. Coleridge Farr, D.Sc., F.N.Z.Inst.)

As a delegate from the New Zealand Institute, I had the honour and great pleasure to visit Japan on the occasion of the third Pan-Pacific Scientific Congress which was held there, and now desire to report on that visit.

As a Physicist and from a scientific point of view, I confined my attention solely to Physics, Geophysics, and cognate branches of knowledge. My report will, therefore, relate to these alone, and I shall leave other delegates to make such remarks as they may think necessary on the branches of science which interest them.

Before, however, dealing with the main subject of the report, I desire to make several observations of a general character.

The organisation of the meeting was remarkable for its completeness and thoroughness, and is a great credit to those who had to do with its development. On entering Japanese waters at Nagasaki, a port at least 850 miles from the City of Tokyo, where the meeting was held, we were met by an emissary from the Conference—Dr. Oshima—and from then till the moment of sailing again from the same port four weeks later we were not without the assistance of honorary guides, who were Japanese gentlemen, who could speak English fluently. I believe similar guides met every arriving overseas party at their port of arrival, and that each party was also “shepherded” in the same way as we were throughout the tour. The amount of strenuous effort on the part of the guides must have been tremendous. They took control of all the baggage—and I did not hear of a single instance of loss—they made all the necessary arrangements regarding sleeping berths in the trains, they provided meals where the travelling was done in trains which had no dining-car, in fact they saw to all details, and seemed to leave nothing whatever to chance. The benefit of this in a land with a foreign and absolutely unknown language cannot be imagined, and only became apparent to us on those occasions when—breaking away from our guides—we attempted to make our own way about in some of the cities. Progress then, if not impossible, became exceedingly slow. The people one met were courtesy itself, but could not understand what was wanted, nor could we understand their answers, and it was therefore necessary to light at length upon some person who did understand something of the language one was speaking.

In all other respects the organisation of the meeting was at an equally high level.

*Japanese Courtesy.*—Perhaps it may not be out of place to make a few observations upon this delightful feature of Japanese life which impressed itself upon so many of us upon very numerous occasions. The Japanese seem—as was stated by a speaker at one of the functions that were held—to be a nation of gentlemen—they appear to be as courteous amongst themselves as they certainly were to us. One could notice the most polite meetings and partings of Japanese who did not know they were being observed. The school children that one met—and they were everywhere to be seen—were friendly and orderly amongst themselves, and prettily responsive to greetings from us. I heard of no unpleasant incident, but I, myself, had many examples of courtesy which would be exceptional in some other parts of the world. Not once nor twice, but many times, I have asked my way to a place from a person who understood what I wanted, but whose answer I was unable to comprehend. On every such occasion he would answer, “I will show you,” and would go perhaps half-a-mile out of his way to do so. Or if a Rikisha or motor-car was available he would call it and give directions to the man. Courtesy seems to be a natural and very pleasant trait in Japanese character.

*The Scientific Aspect of the Meeting.*—If the Congress left anything at all to be desired it was more time for the reading and discussion of papers. In all some four hundred papers were sent in, which had to be got through in ten days. This necessitated very strict time limits being im-

posed upon authors and speakers, and it was a very exceptional paper that could be given more than 10 minutes. Though, no doubt, it would be well to have more time, yet such restriction is not so bad as it might seem. Fairly complete abstracts were available, and were often read in place of the paper. These abstracts were printed and distributed on the morning or afternoon that any particular paper came on, and it could thus be seen in advance what the paper was about, and as all the delegates were staying at the same hotel in Tokyo, there were many other opportunities for discussion. It was in the hotel that some of the most valuable discussions took place, between perhaps the author of a paper and others who might be interested. It is often the case in scientific meetings such as this, that informal discussions arising perhaps out of papers read are more productive of good than the actual hearing of the papers. To appreciate fully the work described by an author in a written paper, it is necessary to read and study the paper and in Physical and Mathematical Papers it is frequently important to work out anew the author's mathematical reasoning. For this the publication of the paper is essential, and in the present case most, if not all of the papers read, will, in due course, be published. And so it is that although the number of papers offered was very large for the time available, yet I think all the delegates felt that this did not militate against the success of the meeting to the extent which it might have been expected to have done by those who were not present. In future meetings it may, perhaps, be well if a previous censorship of papers is instituted, so that only those of outstanding importance shall be read.

*Constitution of the Congress.*—Up till the present meeting I believe the meetings of the Conference have been conducted without any very definite constitution or by-laws, such being left to the President, and to the discretion of those organising the next forthcoming meeting—that is to say to the Local Organising Committee at the place of meeting. At the Tokyo meeting just passed, however, a definite Constitution and By-laws were drawn up, and received the approval of the Conference as a whole. By this Constitution, the name of the Conference is now "The Pacific Science Association," and its meetings are to be held at intervals of not less than two and not more than five years. The Constitution consists of fifteen clauses, of which Clause 4, relating to the Constitution of the Council, is probably the most interesting and important from the point of view of the New Zealand Institute. The administrative work of the Association is arranged to be carried on by a Council of not more than fifteen members, the seats on which Council are allocated to "Countries," of which eleven or twelve are named in the Constitution, leaving three or four vacancies for countries that may at some future time desire to come in. The countries so far named are: United States of America, Canada, Australia, France, Great Britain, Hawaii, Japan, Netherlands, Netherlands East Indies, New Zealand, Phillippine Islands, and Russia, and for these countries, the country shall be represented on the Council by one member for each country, who shall be elected by its National Research Council, or by some other scientific organisation of recognised standing. The scientific bodies thus having electoral powers are named in the Constitution, and in the absence at present of a National Research Council, the New Zealand Institute has been named for New Zealand.

Amongst the by-laws which consist of fourteen Articles, there is one (Article 7) for which perhaps we may be grateful. It provides that the usual Language of the Congress shall be English.

Other than these matters, there does not seem to be anything in either the Constitution or in the By-laws of sufficient local interest to draw attention to.

*Visits to Scientific Institutions.*—This journey to Japan presented exceptional opportunities for visiting and obtaining information about the activities of any particular Scientific Institution there in whose work one might be interested. In most cases visits of a large body of delegates to these institutions was a part of the programme of the Congress, but at such visits the greatness of the numbers present prevented many questions being asked, or much individual attention being given to any particular visitor. They were, however, most valuable as they showed all who took part in them

how much Japan was doing in the cause of science. One had, however, only to express a wish to see any particular institution, and a more or less private inspection of it was most willingly and most courteously arranged. In this more complete way one was enabled to see many most interesting organisations, the work of some of which will now be referred to.

*The Aeronautical Research Institute at Tokyo.*—This Institute is, and always has been, a part of the Imperial University of Tokyo. The first of the Ordinances which govern it states that the Aeronautical Research Institute shall be attached to the Tokyo Imperial University, though its present location is some miles from what is actually the Imperial University Building.

It concerns itself with the investigation of all subjects relating to aeronautics, a term which it wisely interprets in a very broad manner. It is a development of the "Investigation Committee on Aeronautics," which was founded under the chairmanship of Dr. A. Tanakadate in 1916. The Research Institute dates from 1918, and like most other Tokyo institutions was very seriously damaged by the 1923 earthquake. It is, however, rebuilt sufficiently to enable work to be carried on there pending the completion of a much larger and more complete Institution at another part of the city. Much might be said about this institution, but in the limits of a report only a few of the points which were most interesting to myself can be referred to. The work of the Institution is divided into twelve Departments, which are as follows:—

The Departments of Physics, Chemistry, Metallurgy, Materials, Wind Tunnels, Aero Engines, Aircraft, with sub-departments of Instruments and Aeronautical Psychology, Central Library, Workshop, Office.

It will be seen that at the head of this list of departments, which is taken as it stands out of a report of the Institute, the Fundamental Sciences of Physics and Chemistry are recognised as of the first importance in progress. This is the case in all the Japanese Research Establishments of this sort, and there are very many of them. Without progress in the Fundamental Sciences, progress in the applications is impossible. I was very much struck with the work in these departments, and with the width of interpretation adopted. The whole Institution is under the general control of Baron Shiba, who most kindly showed me over it. The liberal staffing of the various departments is worthy of more than passing notice. Thus the Physical Department has five chief investigators, nine senior assistants, seven junior assistants, and two laboratory attendants. The Chemical Department has seven chief members, one senior assistant, five junior assistants, and one laboratory attendant. The Aero Engine Depot has eight chief investigators, twelve senior assistants, fifteen junior assistants, and twenty-two laboratory assistants, and so on throughout the whole of the Institute. The subjects under investigation at present are some nineteen in number in the Physical Department, nine in Chemistry, five in Metallurgy, two in Materials, seven in Wind Tunnel Department, thirty-three in the Aero Engine Department, eleven in Air Craft Department, five in the Instrument Department, and seven in the Aeronautical Psychology Department, making in all about 100 different subjects which are under investigation in this one Institute of Aeronautical Research alone. Many researches have been completed and have led to results of great value, and one finds amongst these such subjects as the Transverse Vibrations of Elliptic and Rectangular Plates, The Content of Helium and other constituents in the Natural Gases of Japan, and many many others. The bearing of the first of the subjects mentioned is, of course, in connection with the vibrations of Aeroplane Wings, and that of the second is for the inflation of dirigible balloons. One must visit Japan to realise what is being done in institutions like this—one institution that is to say, whose whole object is research, and I think one should spend a much longer time there than I was able to do, to appreciate fully what is going on. It is there and at similar places that every advance in scientific method is examined, and if it is possible, some application of it is made to the practical problems under consideration. The remotely, or seemingly remotely-connected subject of Piezo Electricity finds a most valuable use in the investigation of the pressure of piston rings and

the wearing of cylinder walls. Electric valves find an application here to the examination of the rate of dissemination of the gaseous charge to different parts of the cylinder. Very much more could be said about this interesting institution at which, owing to the courtesy of Baron Shiba, I was able to spend an all-too-short morning, but it is after all only one of many other similar places and I must refer to some of the others.

*The Institute of Physical and Chemical Research.*—Perhaps the best way to begin my remarks upon this will be to quote from a pamphlet which was published this year concerning it:—

"The Purposes of the Institute." "The Institute conducts investigations in the pure sciences of Physics and Chemistry, aiming at their industrial development, and at the same time engaging in applied research. No undertaking, whether it be in industry or in Agriculture would be able to attain sound development unless it was based on Physics and Chemistry. Particularly in such a densely populated country as Japan, where industrial materials as well as other commodities are not ample, it is essential to aim at the development of industry by having recourse to science, thereby promoting national interest. The object of the Institute is to perform this important mission.

*Industrial Experiments.*—When any Physico-chemical applied research is completed in the laboratory, it is tested for its industrial applicability, and in case the test shows an appropriate result, arrangement for manufacture is carried out at the Institute; or the manufacture may be entrusted to others; or a new company may be established on the basis of a remunerative contract with the Institute, depending upon the nature of the work. At present there are several undertakings that have already existed as industries or are going to exist as such. As the fundamental cause of success in these applied researches lies in there being sound scientific investigations at the back of them, a part of any profit accruing to the Institute is allocated to the investigation expense of pure science and a further part is given as a reward to the inventor or discoverer."

The staff of this institution numbers three hundred and eighty-four, of whom two hundred and sixteen are directly engaged in the investigations. The number of distinct lines of research pursued is this year one hundred and seventy-one, whilst last year it was one hundred and fifty-four. The results of the researches are published, very often in the English language, but they do not appear, as a rule, in any of the more generally recognised Scientific Journals which we see, at any rate in New Zealand; and I have, therefore, asked that copies of any papers that may come out should be sent to us, and I think it would be well if some recognised library, such, for instance, as the library of the New Zealand Institute, should make a formal application, through its librarian or its president, for copies to be sent it. I feel sure that such a request would be readily granted.

Glancing through a list of the investigations which was very kindly given to me, one would hardly realise that this Institute of Physical and Chemical Research is, like the Aeronautical Research Institute, utilitarian in its work. But the Japanese have realised that for the industries to attain a sound development it is an absolute essential that they should be based upon the fundamental sciences of Physics and Chemistry, and that any advance in these means a hundred-fold corresponding advance in the Industries and in Agriculture. They therefore interpret the Charter in the broadest possible spirit, and amongst the one hundred and seventy-one distinct investigations in progress in the Institute, there are to be found those relating

- (a) to the transmutation of mercury into gold
- (b) the calculation of mutual and self inductance
- (c) photo elasticity
- (d) the manufacture of synthetic sake
- (e) the by-products derivable from waste human hair

and one hundred and sixty-others. The greatest freedom is given to the investigators in their work, they are free to undertake or reject any proposed problem. They are experts in their work and are treated as such but they receive some benefit of a financial kind for any practical applications of their work. I had the benefit of spending an afternoon at this most interesting institution, and was most kindly shown round by Professor Nagaoka, whose scientific reputation is well known, and by Viscount Okochi, who is the "Superintendent and Director" of it.

The time available was, of course, much too short to appreciate all, or nearly all, that was going on at this most interesting establishment, and very little of the work could really be seen, but what I did see showed how complete and efficient the methods of investigation were, and what a valuable stream of knowledge is issuing from it.

The Institute was founded only nine years ago, and its income is derived from an endowment of over £600,000, about one sixth of which was an Imperial gift, a third was a Government subsidy, and the other half consisted of contributions from official sources as well as from individuals. The income is, now, no doubt, being augmented by its interest in the rights of some one hundred and forty patents which have been obtained as the results of investigations carried out at the establishment.

*The Research Institute for Iron, Steel and other Metals at Sendai.*—It is a remarkable thing, and one to be noticed, that many of the "practical" research institutions of Japan are connected with Universities. The Iron and Steel Institute is a part of the Imperial University at Sendai, and the Aeronautical Institute is part of the Imperial University of Tokyo, whilst the Institute of Physical and Chemical Research is connected closely with the Tokyo Imperial University. This fact becomes more and more impressive the more of these institutions one is able to obtain information about. The Iron and Steel Institute began in a somewhat small way in 1915 to deal with problems arising out of the War, but its scope has been rapidly enlarged until in 1924 its staff was very large, seemingly about 100 persons, with Professor Honda, a man whose reputation has been recognised in Europe for many years, at their head. The Research Staff consists of 20 gentlemen, all of them men of distinction and learning.

Forty-one questions have been the subjects of investigation since September of last year, of which a few may be enumerated, though these are picked at random from the list. Some of the forty-one are for example:

- (a) The viscosity of molten metals and alloys
- (b) Comparative investigations of hardness testers.
- (c) Investigation of magnetic sands
- (d) The effect of sulphur on Iron and steel.

The Institute publishes its results—or at least some of them—in the Science Reports of the Tohoku Imperial University in European languages, and has thus published in some accessible European languages no less than one hundred and forty papers. The knowledge contained in these papers must be a very mine of information for those engaged in metallurgical questions, and it speaks most eloquently for the broadness of the view that the Japanese adopt, that they have published these papers in a European language—as indeed they do most of their papers in every institution. In the vast majority of cases the language used in recent years is English.

The regulations with regard to patent rights arising from work done in the Institute are well worthy of study, more especially as similar questions will crop up in connection with the Department of Industrial Research which is about to be established in New Zealand.

*The Geophysical Laboratory at Beppu.*—This laboratory, which is a part of the Imperial University of Kyoto—though it is several hundred miles from it—has only recently been established. So far no publications have issued from it, though a good deal of work is in hand. The laboratory is situated in one of the principal hot spring regions of Japan. The work undertaken there consists of researches, amongst others, into changes of level, temperature, hydrogen and chlorine ion content, and electrical conductivity of the hot spring waters. Microseismographs magnifying fifty thousand times are to be seen there, and the institution is undoubtedly being established at Beppu on a very broad and valuable basis. Indeed, it

might form a better model upon which to establish our own proposed vulcanological station than the Hawaiian Vulcanological Observatory. The latter is perhaps more concerned with the activities of a living volcano, whereas this Geo-Physical Laboratory is in a region not very unlike Rotorua, although perhaps of rather less activity than Rotorua. I was able to spend an all too short time at the laboratory. Dr. Shida, of the Geophysical Department of the Kyoto University, is in charge of the laboratory, and many of the instruments in use in it are of his own design.

*Research in Japan.*—What I have said refers to the institutions that I was able—in the exceedingly short time available—to visit. I am afraid it gives a most imperfect idea of the work that is going on in them, and it certainly gives no idea of the amount of research in progress in Japan. Besides the work at institutions mainly intended for that purpose, and to deal at all with these would need a volume rather than a short report, besides these, an immense amount of first-class research work is done at the Universities themselves, but I shall refer to them again shortly. There are forty-five Government or Municipal Research Institutions in Japan. As well as these there are twenty-five other institutions, either privately endowed or maintained by business firms. One of these is the Institute of Physical and Chemical Research already referred to, and this number does not include Observatories of which there are many. The average number of research “experts” employed in these institutions is about 23, which number does not include those who are classed as “assistants,” and who are very much more numerous, probably at least double as many. Thus the average institution is a very large institution, and as far as I have been able to judge the “experts” are most exceedingly competent men, and it does not include either the Observatories nor the Universities, and as I have said before, an exceedingly large amount of research work is done in institutions maintained by the Universities.

*The Imperial Universities.*—There are six of these, namely Tokyo, Kyoto, Sendai, Tohoku (at Sendai), Kyushu at Fukuoka, Hokkaido, and Keijo. There are also other Universities known as private Universities, to which I shall not refer. The staffing of these Universities is to a New Zealander exceedingly liberal, but it accounts for much that it would be otherwise impossible to explain. I shall refer in any detail only to the Imperial University at Tokyo, and also that at Kyoto, as these were the only ones I had an opportunity of seeing. The Tokyo University, besides teaching its students, or rather, perhaps, as an aid to teaching its students, maintains the following institutions:

- (a) The Tokyo Astronomical Observatory
- (b) The Earthquake Research Institute
- (c) The Aeronautical Research Institute
- (d) The Institute for Infectious Diseases
- (e) The Seismological Institute
- (f) The Botanic Garden
- (g) The Marine Biological Station

as well (evidently) as some others.

The Kyoto University has associated with it:

- (a) The Astronomical Observatory
- (b) The Kamigamo Seismological Station
- (c) The Beppu Geophysical Laboratory
- (d) The Seto Marine Station; and
- (e) The Otsu Hydro-Biological Station.

These are, of course, in addition to the usual laboratories which are to be found in every modern University. The general policy and mode of working of these Universities can, perhaps, be seen from considering one department in one of them, and the one I naturally choose is that of Physics at Kyoto. The Department of Physics is divided there into three sub-departments, viz.:

- (a) Physics;
- (b) Cosmical Physics; and
- (c) Geophysics.

The sub-branch physics has in it four professors three assistant professors and two lecturers, and I was informed that there are less than 60

students taking the subject. The sub-branch Cosmical Physics has two professors and two lecturers; I do not know how many students there may be. The sub-branch Geophysics has three professors, two assistant professors and nine lecturers. The liberal scale of staffing is thus apparent, and amounts in the sub-branch Physics to less than seven students per teacher. The students, too, are older and more matured than ours, and I am told that their average age is about twenty-two years. Such a system produces first-class men, and moreover so restricts the field of study of the professor or teacher that he is enabled to be really an expert in his branch, rather than a man who perhaps knows something of every branch and knows none of them well. The cost of such a system is, of course, proportionately high, but that Japan finds that it pays is shown by the figures relating to the Kyoto University, which are taken from the Kyoto University Calendar for this year. The University is a very modern institution, boasting only 29 years of existence—it was founded in 1897. The cost of it during that year was approximately £5400 whereas during this present year it is £500,000. As there are something a little under 4000 students at the University (in all grades) this cost is about £125 per student per annum at present. In the whole Department of Science in the University of Kyoto there are 85 teachers. To cover the same work in Canterbury College we have about ten teachers. The number of students in this department in Kyoto is 250, which is probably about what it is in Canterbury College, indeed it may be more at the latter place. And the same kind of thing holds in every department of all the six Imperial Universities of Japan. Japan has realised that the thorough education—specialist education, of course, in every case—of a comparatively few is more the function of the University and pays the Nation better than the cheap and nasty sort of education of a great many. Perhaps I may quote from an Imperial ordinance governing Universities, which was promulgated in 1918. Article One of that Ordinance gives a concise statement of the functions of a University as conceived in Japan. It reads:

“Universities shall have for their objects the teaching of such sciences, theoretical and practical, as are required for the purposes of the State, and the prosecution of original research in the said sciences; and consideration shall be given to refinement of character with an eye to fostering national ideals.”

A narrow view of the word “Sciences” as used above is not taken, and Article Two specifies the departments which may be set up of which “Literature” is one.

It is no doubt in the spirit of this Ordinance that the Universities of Japan are such centres of research. They have realised as someone put it that “The function of a University is not to teach” but that it also has the further function of learning as well, and that by learning teaching is best done. And so these Universities have established such places as the Aeronautical Research Institute, and the Beppu Geophysical Laboratory, to which reference has already been made, as well as a host of other institutions of an analogous sort, and it is to these that the students are drafted as they become more proficient in their work, and they see the work done there as it is done in actual practice, and they advance knowledge at the same time.

In conclusion I may perhaps refer to an opinion which was expressed to me by one of the overseas delegates having special knowledge of the interaction of science and industry. He told me that in his opinion the organisation of the co-operation of the two was more complete in Japan than in any other of the many countries he has visited, which included England, France, the United States, Czecho-Slovakia, and Germany, with the exception of one of them, which was as far as I remember Germany. Thus the work, started in the seventies by Ewing and Ayrton, and Perry, has borne rich fruit for this progressive Empire.

*Pan Pacific Science Congress*:—A motion “That the N.Z. Institute invite the Pan-Pacific Science Congress to meet in New Zealand in 1932 or 1935” was lost.

## TONGARIRO NATIONAL PARK BOARD.

I have to report that two meetings of the Board have been held during the year, one in Wellington, and one at Waimarino. Two meetings of the Central Executive Committee (consisting of the Wellington residents on the Board) have been held in Wellington to deal with urgent business.

I attended all these meetings.

*Heather and Grouse.*—In the past this Institute has emphatically opposed the introduction of any form of wild life into the Tongariro National Park which is foreign to it. (See Annual Meeting, 1924, Standing Committee, September 16th, 1924, and 18th November, 1924, Annual Meeting, 1925 Standing Committee 23rd June, 1925, and 21st May, 1926). During 1926 the Standing Committee passed the resolution recorded in the yearly report, which speaks with no uncertain sound. Details of the treatment of national parks in other lands, notably in the United States and Switzerland, have been received and have been published in the daily press of New Zealand. From these it appears that the policy adopted by the Institute is framed on right lines, and corresponds closely to that of other countries.

The resolution, "That this Board is of opinion that the heather now growing in the National Park should be eradicated," stood in the minutes of the National Park Board. A notice of motion stood on the agenda paper for the December meeting, "That this resolution should be rescinded." At the meeting the Hon. Warden of the Park (Mr. Cullen) informed the Board that during the past twenty years five tons of heather seed had been distributed in the Park and its vicinity. From this it appeared possible that the difficulties attending the eradication might prove insuperable. The following resolution was agreed to as the best method of attempting to cope with the heather question:—

"The Board being of opinion that it is impossible to eradicate the heather save at cost beyond the means of the Board, resolves that no further heather seed be planted, and steps be taken to prevent the further spreading of the heather now growing in the Park. The Board confirms its policy of opposition to the planting in the Park of anything (except under domestication) not indigenous to the Park, and records that the previous resolution to eradicate the heather is thus automatically rescinded together with the permission granted to plant Mount Cook lilies."

As a result of the passing of this resolution, it is expected that further substantial donations for development work from the Bruce Estate may be received.

At a Central Executive Committee meeting held subsequently in Wellington it was resolved that a committee consisting of Messrs. W. H. Field, M.P., E. Phillips Turner and B. C. Aston, examine and report on the present distribution of the heather and demarcate the boundaries of some of the areas so as to form the basis for observation as to whether the heather is spreading. It is hoped to make some enquiry during the coming autumn so that a preliminary report may be furnished to the Park Board at its next meeting. Other important works which the Park Board has in hand are the erection of a hostel and the publication of a handbook to the Park. The Government Architect (Mr. Mair) is preparing an estimate of what can be done with the possible amount which can be made available for the purpose, and Mr. Cowan has completed a book which it is hoped will shortly be published.

Arrangements have been completed whereby the milling operations of the Prisons Department in the Park have been terminated. The price for tent accommodation has been raised considerably. The question of the establishment of an alpine garden is to be considered in conjunction with other projected improvements. It has been decided to fence the Park boundaries near Ohakune at a cost of £70.

The most pleasing aspect of the heather-grouse controversy is the indication of a strong public opinion in favour of the preservation of the national features of the country existing as reserves or parks,—evidence of the growth of a vigorous national feeling.

18th January, 1927.

B. C. ASTON,  
President.

Mr. Elliott moved, "That Mr. Aston be thanked for his report," seconded by Mr. Hill and carried.

## BOARD OF SCIENCE AND ART REPORT.

The President of the New Zealand Institute is a member of the "Science and Art Board Act, 1913." I attended the two meetings of the Board held during 1926. The chief business conducted referred to the publication of scientific handbooks and bulletins and the New Zealand Journal of Science and Technology, the control of which by Cabinet minute is now vested in the Department of Scientific and Industrial Research.

Other matters dealt with were the consideration of a scheme for the establishment of a joint Museum, Art Gallery and Scientific Library, making representations to the Government on the subject of hydrographical survey, representation of New Zealand at Science Congresses outside New Zealand, the establishment of an Archives Department, a Vulcanological Observatory, the Botanical Survey of New Zealand.

Arrangements were also made for the field excursions of members of the Dominion Museum staff, the proposed purchase of museum exhibits, the examination of Kaingaroa rock carvings, the amendment of Turnbull Library Rules.

The reports of several sub-committees were received and the Board endorsed the report of Sir Frank Heath, as follows:—

"That this Board gives general approval to the report of Sir Frank Heath, and considers its adoption would greatly improve the position of industry."

Copies of the Board's Annual Report will be circulated.

B. C. ASTON.

President.

19th January, 1927.

This report by the President was adopted.

## N.Z. INSTITUTE OF HORTICULTURE REPORT.

As the accredited representative of the N.Z. Institute, I attended the meetings of the N.Z. Institute of Horticulture's Dominion Council, the chief executive body of this Institute. A number of meetings of this Council and minor committees have been held during the year under the able Presidency of Mr. Nathan, of Palmerston North. The range of the work to be attempted is a very wide one, including horticultural education, the establishment of a school of horticulture, and the granting of a diploma of horticulture, plant nomenclature, rules for judging plants at shows, town-planning, public lectures, preservation of New Zealand plants and existing types of vegetation, plant registration, horticultural legislation, rock gardening, botanical gardening, national parks, bud selection, citron improvement, etc.

The New Zealand Institute of Horticulture has set itself an ambitious programme, and one sincerely hopes that the science and practice of horticulture may receive a great stimulus in New Zealand through the activity of the Institute. The Institute keeps in touch with all centres by means of a paid organising secretary. The thorny question of finance is likely to be a problem for the first few years of this Institute's existence after which one may predict confidently an established and useful future.

B. C. ASTON.

President.

Dr. Cockayne moved and Mr. Hill seconded, "That the report of the work of the Institute of Horticulture presented by the President, be adopted."—Carried.

*Hutton Memorial Fund.*—Miss M. K. Mestayer applied for £30 for research on Brachiopoda and Mollusca. Professor Chilton moved and Dr. Cockayne seconded, "That the application be granted."—Carried.

*Fellowship N.Z. Institute.*—Dr. Cockayne moved and Professor Park seconded, "That two Fellows of the N.Z. Institute be elected next year."

*National Research Council.*—Professor Farr moved and Professor Worley seconded, and it was carried, "That the formation of a National Research Council, as part of the N.Z. Institute, is desirable."

The following recommendations brought down by the sub-committee were approved:—

- (1) The functions of a National Research Council shall be
  - (a) To consider matters affecting research in New Zealand, and make recommendations on the same to the New Zealand Institute, or to the Government, or to the Council of Scientific and Industrial Research.
  - (b) To advise the Government upon the personnel of the Council of Scientific and Industrial Research (as suggested by Sir Frank Heath).
  - (c) To administer the Government Research grants of the New Zealand Institute.
  - (d) To affiliate with the International Research Council.
  - (e) To nominate New Zealand representatives to International Scientific Congresses.

(2) The members of the National Research Council shall be appointed by the Board of Governors of the New Zealand Institute, but shall not necessarily be members of the New Zealand Institute.

(3) The President of the New Zealand Institute shall be *ex officio* a member of the National Research Council. Including him the number of members shall not exceed 40, and shall be chosen as far as possible in the following proportions—Natural Sciences, including Botany, Geology, Zoology, 12; Physical Sciences, including Physics, Chemistry, Mathematics and Astronomy, 12; Agriculture, 4; Engineering, including Mining and Metallurgy, 4; Medicine, 4; Anthropology, 2; other Sciences, 1.

(4) The members of the Council shall be appointed for a period of four years, but one fourth of the total members shall retire by rotation annually, and shall be eligible for reappointment.

On the motion of Dr. Thomson, seconded by Professor Easterfield, it was carried, "That a scheme for a National Research Council be tentatively approved by the New Zealand Institute and submitted to the Council of Scientific and Industrial Research, and that the ultimate adoption of the scheme be contingent on the provision by the Government of the necessary finances for the functioning of the Council, and for affiliation to the International Research Council."

On the motion of Mr. Eliott, seconded by the Hon. G. M. Thomson, it was resolved, "That the names of the proposed members of the National Research Council be postponed until such time as the

Government approves of the scheme. When this eventuates a special meeting of the Board shall be called for the purpose of appointing such members."

*Hon. Editor.*—The Hon. G. M. Thomson moved a hearty vote of thanks to the Hon. Editor for his excellent work. Carried with acclamation.

*Science Congress.*—It was resolved that the next Science Congress be held in Auckland in January, 1929.

*Fellowship Regulations.*—Dr. Thomson moved the adoption of the amendments to the Fellowship Regulations as proposed by him.

Clause 23: The following shall be added:—"The number to be elected in any year shall be decided by the Board of Governors at the previous annual meeting." This was adopted.

Clause 25: To be amended to read:—"No person shall be nominated or elected as Fellow unless he has been a member of the New Zealand Institute for three years immediately preceding his nomination or for five years at any period preceding his nomination." Adopted.

The remaining proposals were defeated.

A resolution proposed by Dr. Cockayne and seconded by Professor Park, "That a committee be set up to draw up rules based on the election for Fellowship of the Royal Society for the Fellowship of the New Zealand Institute," was lost. A letter dealing with the election of Fellows was received from Professor Sommerville and referred to the Standing Committee with power to act.

*Hon. Members.*—A ballot was then taken for the election of four honorary members, and resulted in the election of Professor H. E. Armstrong, Madame M. M. Curie, Dr. T. A. Jagger, and Dr. T. Mortensen.

*Deceased Honorary Members.*—The President announced that six honorary members, namely Dr. W. Bateson, Professor G. L. Goodale, Mr. Chas. Hedley, Professor Jean Masart, Professor C. F. Norstedt, and the Rev. T. R. R. Stebbing had died, and the vacancies would be filled in the usual manner.

*Type Specimens.*—A letter was received from Dr. Thomson regarding type specimens of native species of plants and animals. Referred to the Standing Committee with power to act.

*Arthur's Pass.*—Dr. Cockayne moved and Professor Chilton seconded, "That the attention of the Department of Lands and Survey be called to the fact that wild flowers gathered in the Arthur's Pass National Park are being publicly sold at Otira and Arthur's Pass railway stations, and the Board of Governors strongly recommends that steps should be taken to prohibit such sale of flowers gathered both in the Park and on adjacent Crown Lands." This was referred to the Standing Committee with power to act.

## REPORT OF THE PUBLICATION COMMITTEE.

Volume 56 was issued on the 12th July, 1926, more than a year after the date expected. It contains 21 plus 860 pages (of which 113 were Proceedings

and Appendix) with 114 plates. The volume contains 62 papers by 48 authors.

A fifth instalment of Dixon's "Bryology of New Zealand" has been received, and will be printed early in 1927: this part will be accompanied by a plate. There will be one more part, with index, when the whole will be completed.

Owing to unavoidable delays which have continually deferred the issue of the volume during the past few years, tenders were called for the printing from outside firms, and the tender of Messrs. Ferguson and Osborn was accepted. The material ready was handed to the new printers as soon as possible, and it was hoped that this Volume, No. 57, might have been laid on the table. Practically the whole of it is in type, over 500 pages are in page form, and the first authors' copies were issued on 9th October, 1926, only three months after Volume 56 had been issued. Volume 57 will therefore, be out in February, when the quarterly issue will be begun with Volume 58.

JOHANNES C. ANDERSEN,

For the Publication Committee.

This report was adopted. On the motion of Dr. Farr, seconded by Professor Worley, it was resolved, "That in view of the fact that the price charged by the Government Printing Office for printing the Transactions has been greatly in excess of that now charged by a private printing office, the Minister be asked to look into the amount charged for the last three volumes with the object of either wiping out or greatly reducing the amount debited to the Institute by the Government."

*Observatory Boards.*—Letters were received from Dr. Marsden asking for nomination of four representatives of the Institute on a Board of Advice for the Dominion Observatory. On the motion of Dr. Farr the following were nominated for both Boards:—Professors Farr, Burbidge, Sommerville and Mr. Gifford.

*Date and Place of Annual Meeting.*—On the motion of the Hon. Mr. Thomson it was resolved that the next Annual Meeting be held in Wellington on the last Thursday in January, 1928. Carried.

*Travelling Expenses.*—Mr. Elliott moved that the travelling expenses of the Board of Governors be paid. Carried.

*Votes of Thanks.*—The Hon. Mr. Thomson moved and Mr. Hill seconded, a cordial vote of thanks to the officers and to those providing afternoon tea.

The following officers were elected for 1927:—President, Mr. B. C. Aston; Hon. Secretary, Dr. P. Marshall; Hon. Treasurer, Mr. M. A. Elliott; Hon. Editor, Mr. J. C. Andersen; Hon. Librarian, Professor Sommerville; Hon. Returning Officer, Professor H. W. Seager; Managers of Trust Funds, Mr. M. A. Elliott and Mr. B. C. Aston.

*Research Grants Committee.*—Professors Chilton (convener), Farr, Speight, Dr. Hilgendorf, and Mr. A. M. Wright re-elected.

*Library Committee.*—Professors Sommerville, Kirk, Cotton, Dr. Thomson re-elected.

*Hector Award Committee.*—Sir E. Rutherford, Professors Farr (convener), and Vonwiller.

*Hutton Award Committee.*—Drs. Marshall, Holloway, and Thomson (convener).

*Finance Committee.*—Mr. Elliott (convener), Mr. Aston, Hon. G. M. Thomson, Professor Segar, Dr. Thomson, and Mr. A. M. Wright.

## PRESIDENTIAL ADDRESS.

Gentlemen of the Board of Governors,—

It is my first and mournful duty to refer to those members who have gone. Death has made a gap in the Roll of Honorary Members which takes away six names honoured in the Science of Zoology and Botany.

Dr. William Bateson, F.R.S., born in 1861. He became distinguished for his work on genetics. Elected Honorary Member, 1915. Died 8th February, 1926.

Professor George Lincoln Goodale, born in 1839. He succeeded the celebrated Asa Gray as Professor of Botany at Harvard University, U.S.A. Elected Hon. Member 1891, when he attended the Christ-church meeting of the Australasian Association for the Advancement of Science. Died early in 1926.

Mr. Charles Hedley, F.L.S., born in 1862. He was one of the world's leading conchologists, and was elected Honorary Member 1924. He died at Sydney, 14th September, 1926, beloved by many friends and fellow-workers in New Zealand.

Professor Jean Massart, born in 1865. He became Professor in the University of Brussels. A distinguished botanist, he was elected Honorary Member in 1916, and died in August, 1925.

Professor Carl Fredrik Otto Nordstedt, Ph.D., born in 1838. A distinguished Swedish algologist, he was elected Honorary Member in 1890, and died 6th February, 1924.

Reverend Thomas Roscoe Rede Stebbing, F.R.S., born in 1835. A distinguished naturalist and worker in the group Crustacea, he was elected Honorary Member in 1907, and died 9th July, 1926.

Of the New Zealand members we mourn the loss of Joseph P. Frengley, M.D., born in 1873. He was formerly chief of the New Zealand Health Department. He made a study of Municipal Milk Supply, and it is largely owing to his efforts that the excellent milk distributing system of Wellington City was adopted. He died on 1st August, 1926.

William Townson, born in 1850. He was for many years a keen botanical explorer, being exceptionally diligent and successful in the Westport district. His name is perpetuated in the genus of orchids *Townsonia*, discovered by him and named in his honour. He died 11th August, 1926.

Sir Arthur M. Myers, born in 1867. He was an able Minister in the War Cabinet; he gave the Myers Park to Auckland City, and was prominent in many movements for the public good. He died 9th October, 1926.

J. T. Ward, Honorary Director of the Wanganui Observatory. He was prominent in imparting astronomical knowledge, and himself constructed the Wanganui telescope, and published many valuable observations. He died on the 4th January, 1927.

Considering the time that can reasonably be allotted to a Presidential Address to this business meeting it is desirable to speak only on those subjects which touch directly on the work of the Institute.

The year 1926 proved a very full one for the officers, the absence for a part of the year of the Honorary Secretary threw an additional load of work on the Honorary Editor. The Assistant Secretary and Librarian, Miss Wood, has by her diligent attention to details, her organising capacity, and her unfailing cheerfulness under difficulties, considerably lightened the burden of the Honorary Officers. I think the desirability of providing the Assistant Secretary with a cadette in the near future, should be kept steadily in view. A new method of circulating the works in the library to research workers and others has been inaugurated by Miss Wood, and is, I understand, giving satisfaction.

Incorporated societies have been kept well posted concerning the work of the Institute. It is desirable that all members of the Board who visit Wellington at definite times should notify the Assistant Secretary, so that arrangements may be made for them to attend committee and other meetings. The establishment of a College of Agriculture at Palmerston North is now definitely decided, and the advent of new blood into the community may stimulate the Manawatu Philosophical Society, which has presented no reports for two years, into renewed life.

A word may be said as to the President's duties. He represents the Institute on two important bodies by statutory enactment, the Tongariro National Park Board, and the Board of Science and Art. In the latter case, under the Science and Art Act, 1913, he has the power to appoint a deputy to act fully as a member of the Board. It is regrettable that there is not some such provision in the Tongariro National Park Act, 1922. In the New Zealand Institute, the President is elected annually, and it has become an unwritten law that the same person does not take office for longer than two years. Other members of the Park Board hold office for four years, and are eligible for re-election. Hence the scientific representative is at a decided disadvantage, for by the time he gets fully conversant with the business of the Board and the theatre of operations he has to retire without a chance of re-appointment as the Institute's representative. Again, in the case of the New Zealand Institute of Horticulture, the New Zealand Institute may elect anyone, not necessarily the President, to represent it on the Dominion Executive Council, a practice which allows of a continuous representation and makes for efficiency and continuity of policy. To bring about an improvement in the representation on the Tongariro National Park Board, it should be possible for provision to be inserted in the Act allowing the New Zealand Institute to appoint a deputy in place of the President.

The outstanding events of the past year are:—

- (1) The visit of Sir Frank Heath, and the publication of his comprehensive report.
- (2) The transfer of the Institute's printing from the Government Printer to a private firm.
- (3) The opening of the Wilton's Bush Open Air Plant Museum.

Other subjects which must be mentioned are:—

(4) The formation of a branch of the Institute of Chemistry in New Zealand.

(5) The successful publication of a valuable work on Australian and New Zealand Insects by Dr. Tillyard, F.R.S., and

(6) The grant of a considerable sum by an Imperial Department for research in New Zealand.

*Scientific and Industrial Research Department and Sir Frank Heath's Report.*

There are now three bodies in New Zealand each deriving authority from a different Act of Parliament, but having similar aims and functions.

The New Zealand Institute derives authority from the New Zealand Act, 1908, consolidated from the New Zealand Institute Act, 1903, which had been reconstructed from the New Zealand Institute Act, 1867. The title of the last Act was "An Act to establish an Institute for the Advancement of Science and Art in New Zealand," which may be taken in the broadest sense to be the functions of the present Institute.

The Science and Art Act, 1913, is entitled "An Act to provide for the constitution and control of a Dominion Museum, Art Gallery and Library, and for the production of certain Scientific Works."

The Scientific and Industrial Research Act, 1926, has the title "An Act to make provision for the promotion and organisation of Scientific Research, and for its application to the primary and secondary industries of New Zealand." The last Act provides for the appointment of an advisory council, but no provision is made whereby the New Zealand Institute is represented on the Council. This Council has been appointed and is especially strong on the Medical, Engineering and Chemical side. One looks for some means of bringing the Council into co-operation with the New Zealand Institute which is strong on the botanical, zoological, and geological side.

The means by which the New Zealand Institute, or its incorporated societies, promotes science are chiefly the publication of original researches and memoirs, the organisation of scientific congresses, excursions, expeditions, and lectures, the administration of trust funds for promoting scientific work, the making of grants towards the expenses of carrying on research, the rewarding of scientific workers of merit by means of money prizes, medals, and titles, the institution and development of scientific libraries and museums, and making recommendations to the Government.

The Science and Art Board concerns itself mainly with the control of the Dominion Museum, and the publication of Government Scientific Memoirs and Papers, which latter duty will in future, if Sir Frank Heath's advice is followed, be transferred to the Department of Scientific and Industrial Research.

The Scientific and Industrial Research Department is constituted to deal with applied science and industries, and control the scientific departments of the Government other than those of the Department

of Agriculture. This new Science Department is directly the result of the visit to New Zealand in February, 1926, of Sir Frank Heath, K.C.B., the Secretary of the English Department of Scientific and Industrial Research. The valuable report of this high imperial officer, "Organisation of Scientific and Industrial Research in New Zealand," dated 12th March, 1926, was presented to Parliament under covering memo of the Prime Minister, dated 25th May, 1926, and as soon as copies were available they were distributed to Governors of this Institute. Sir Frank Heath met the members of the Board of Science and Art, who afterwards passed a resolution to the Government approving of his report. Sir Frank also met the Standing Committee of the Institute and discussed matters. The Standing Committee resolved that in view of the extreme importance of Sir Frank Heath's report it offer its services to the Government in any direction in which it can be of assistance. Sir Frank Heath's references to the New Zealand Institute are as follows:—

"I recommend that the present grant to the New Zealand Institute be continued; that they be assisted to pay off their heavy overdraft to the Government Printer: and that thereafter they be required to make their own arrangements for printing."

It is to be noted that in respect to this, the assistance which has been granted the New Zealand Institute is the permission to pay off the outstanding Government Printer's Account in instalments, interest being charged on the unpaid balance at the rate of 5 per cent., and to transfer the printing to a private firm at once.

Paragraph 67 of Sir Frank Heath's report states:—

"The central authority (of the new Department) should enter into an agreement with the New Zealand Institute to prevent any overlapping between their own grants and those of the Institute. Such an arrangement has been made with the Department of Scientific and Industrial Research at Home and the Royal Society with very satisfactory results."

Sir Frank evidently anticipated that the Government vote for research in past years to the New Zealand Institute would be continued.

Sir Frank Heath's report (paragraph 69) also deals with the formation of a National Research Council:—

"If the encouragement of scientific research and the organisation of industrial research is to become a declared function of the Government as recommended in this report, it appears to me to be of great importance that the men of science in the Dominion should be encouraged to organise themselves on a completely unofficial basis. Such an unofficial body of the best scientific opinion, if fully representative of all branches of science (including medicine and engineering), would be a most valuable support to the Government in influencing public opinion and by offering friendly criticism and suggestions to the Government on its official policy. The best of Departments is the healthier and better for instructed outside criticism, while occasions may well arise—e.g., the selection of representatives of the Dominion at important international science congresses—when the Government would be glad to seek the advice of an independent body other than itself. The New Zealand Institute has many but not all the qualifications needed in a body of this kind. It is specially strong on the biological side, in geology and chemistry: but it is not representative of engineering, nor of medical science; and I understand that the astronomers have recently formed a society of their own. Moreover, the Board of Governors is in large part elected on a popular basis by local institutes in a manner that gives no assurance of a suitable balance of the sciences in the governing body, while two are

official members, and a further four of its members are appointed by the Government. It is an old and distinguished foundation which is obviously doing most valuable work, and it would be doubtfully wise to suggest any change in its constitution. But it might well be invited by the Government to take a leading part in bringing a body into existence which would be truly representative of the best men the Dominion has in all branches of science. Such a body, if elected by the leading representatives in each field of work, would become the National Research Council for New Zealand. It would become affiliated to the International Research Council, like the National Research Council of Australia. The Dominion would take her proper place in the international world of science, and her council would exercise naturally and inevitably the valuable functions referred to at the beginning of this paragraph. On this Council the Fellows of the Institute would certainly hold an important place."

Clearly Sir Frank has a high opinion of the New Zealand Institute, and his criticism as to the representation of the sciences is worthy of careful consideration by the Institute. I have thought that one way of effecting a better balance of the sciences on the Board of Governors would be for the Government to appoint its nominees on the Board from those sciences which are not at present represented. Thus four Governors could be appointed for medicine and engineering. The Institute has in the past published papers from medical men, and there is no reason why now the *Transactions* are to be printed quarterly, they should not absorb *The New Zealand Medical Journal*. The New Zealand Institute would, I am sure, welcome a larger number of medical men to membership. There may be other similar scientific journals which could be so incorporated. *The Journal of Science and Technology*, for instance, and the *Journal of the Polynesian Society*. This is the day of great mergers in the world of commerce. Science has followed suit in England, especially in the matter of printing. New Zealand must organise and decrease the cost of production of its scientific publications.

*Printing Transfer.*—Arising out of Sir Frank Heath's recommendation is the transfer of the Institute's printing from the Government Printer to a private firm. This step was authorised at the last annual meeting of this Board, the Standing Committee having been given power to act, a contract has been made with a private printing firm to the satisfaction of the Hon. Minister in charge of the Printing Office, to whom all the papers have been submitted. Since 1868 the New Zealand Institute has published the yearly volume of *Transactions and Proceedings* by the same printer who did the work for Government Departments. It was not without serious consideration that a change has been made, as the Government Printer has always given satisfaction for quality of product, but the delay in publishing has become so great that the value of the *Transactions* as a publishing medium has been imperilled. Speed in publication will form a prominent feature in the new arrangement. It is hoped that Volume 57 will be issued in a few weeks, and the following volume will be issued in quarterly parts. With the quarterly publication, the contents of the *Transactions* might be made to appeal to a wider audience. The appointment of a body of abstractors to send in matter from their own districts on science subjects should be attempted. Abstracts of papers concerning New Zealand matters published in overseas science journals should be a special feature. It should

certainly be the duty of those abstractors to see that every paper of merit not published in the *Transactions*, but containing the result of original scientific work on a subject which has a peculiar interest for New Zealand is abstracted, however briefly, in the *Transactions and Proceedings*, and the author himself, if in New Zealand, would no doubt be glad to prepare a brief abstract. In the case of new manuals and works of reference, the Hon. Editor would, of course, see that they were adequately reviewed. In this way the quarterly *Journal of Transactions and Proceedings* may be made to become an indispensable reference work on science in New Zealand, and the anomaly that such monumental works as Thomson's *History of Acclimatisation in New Zealand*, Guthrie Smith's *Tutira*, and Cockayne's *Vegetation of New Zealand*, can be published and remain unnoticed in a Journal devoted to New Zealand science may disappear.

Of course such amplification of the Institute's publishing functions will throw more work on the Hon. Editor, but with local abstractors, and the help of the Assistant Secretary, the *Transactions and Proceedings* as a quarterly Journal may be made to appeal to a greater range of readers. Long articles might be separated by the authors into suitable parts to be spread over the whole year.

Now the *Transactions* is to appear quarterly, the propriety of accepting approved advertisements should be considered as a method of augmenting this Institute's income.

With regard to the quality of the new printer's work, those authors' copies which have already been circulated have given satisfaction. With regard to expense I would refer you to the Hon. Treasurer's statement, but I may say that at present this may be regarded as the most satisfactory feature in the change.

The question of finance naturally follows the last subject. I consider that a strenuous effort should be made to increase the income of the Institute. The membership of each society might be increased by an active personal canvass by some well-known member or members of each society working together. The levy on the societies should certainly be raised as suggested by a former President, Professor Easterfield, in his 1922 address, so as to enable the Standing Committee to pay off more of the heavy indebtedness. In addition, I would suggest that an appeal be made by circular and personally to all bodies and trusts who are willing and able to help forward scientific work in New Zealand for a donation to the printing fund. I would ask for the appointment of a finance committee with representatives from all larger societies for the purpose of organising an appeal in each district. It is essential if the New Zealand Institute is to promote science successfully that the governors should be free from the cares and limitations of the debtor.

The Government annual statutory grant to the New Zealand Institute is now paid under the authority of Section 7 of the Finance Act, 1925, the section of New Zealand Institute Acts authorising Government grants having been repealed in order to increase the amount granted. It is desirable that the acts and portions of acts dealing with the New Zealand Institute should be consolidated.

I have also to remind the Board of the necessity for providing a building fund. The desirableness of this has already been admitted at the 1924 meeting of this Board (see p. 776, vol. 55). This is a matter which should perhaps stand over until the more important printing debt is paid.

The Assistant Secretary informs me that difficulty is experienced in collecting debts due to the Institute. Some authors are in arrears two or three years for their copies, and other accounts for books supplied are not being paid punctually. To remedy this state of things, I suggest that all accounts be increased 20 per cent. which surcharge shall be remitted if the debt is paid within a reasonable stated time.

*Establishment of a National Botanical Garden.*

In 1924 I drew attention to the need of a National Botanical Garden (*New Zealand Journal of Science and Technology*, July, 1924, vol. 7, No. 2, p. 128):—

"The scattered distribution of the finest plants of New Zealand prompts the question whether it would be possible to grow them all in some well-selected site to form the nucleus of a national botanical garden. Here an endeavour might be made to bring together the noble sub-antarctic element of our flora already mentioned, the East Cape and the Marlborough endemic plants, the Stewart and Chatham Islands tree composites, and all the beautiful alpine plants of both islands. Provided that some such mountain as Mt. Egmont were chosen, stretching from sea-level to beyond sub-alpine heights, the writer sees no reason why all the native plants could not be grown successfully. Already there are National Parks at Mount Egmont, Mount Ruapehu, and in the Fiordland with custodians, rangers, and caretakers. There are sanctuaries and caretakers for them. Could not a beginning be made on one of these sites, and a national arboretum or botanical garden established under conditions which would assure its perpetuity? The fault of private or even municipal gardens is that, when collections of New Zealand plants are established, the life of the collection is synchronous with the life of the collector. Private collections are obviously fated to untimely ends, and public collections are subject to like fate owing to change of management. It seems that the foundation of such an institution as here proposed would be a very fitting commemoration of not only the life labours of those eminent botanists who have gone, but of those who are still with us."

The *English Gardener's Chronicle* (20th December, 1924, reprinted in *New Zealand Journal of Science and Technology*, December, 1926, p. 383) in commenting on this proposal states:—"It comes as something of a shock to realise that New Zealand, in spite of its wonderful flora, and the variety and beauty of the plants in the Islands not far removed therefrom, possesses no national botanic garden." Mr. W. R. B. Oliver in the same *Journal* (1926, vol. 8, p. 227) has emphasised the necessity for making a national collection, and suggests Mount Egmont for alpine plants. Since then, owing to the enthusiasm of Dr. L. Cockayne, the Wilton's Bush Reserve of the Wellington City Corporation has been formally opened, in the presence of a large and distinguished gathering, as an open-air museum for New Zealand plants, where an attempt will be made to grow them, (a) as isolated specimens, (b) in association with each other as they occur in nature, an entirely novel undertaking. One hopes this new municipal departure will succeed, and that an arrangement will be made by means of deed of trust and suitable endowment

to ensure perpetuity for this open-air museum. It is remarkable that large sums are spent annually in maintaining collections of live foreign animals in zoological gardens while there is no national botanical garden where may be exhibited the unique New Zealand plants. That such a state of things can exist is most puzzling to residents in centres of culture beyond the seas, where the plants of New Zealand are in great demand and treasured for their beauty.

*Formation of a New Zealand Branch of the Institute of Chemistry of Great Britain and Ireland.*

The Institute of Chemistry was founded in 1877, and incorporated by Royal Charter in 1885. The chief functions of the Institute are the examination of the qualifications of those who wish to practice the science as a profession by granting to those approved a certificate and watching over their interests, and generally advancing the science as a profession. There are now over 4,000 Fellows and Associates, and some 400 students, and practically all private and public analytical chemists and most professors and lecturers in chemistry hold the Institute's Fellowship or Associateship. The New Zealand members of the Institute met in November, and have asked the London Council to permit the formation of a New Zealand Section to create a local organisation for the acquisition and dissemination of useful information connected with the profession, to maintain the status and advance the interests of the profession, to arrange conferences and social meetings, and the delivering of lectures. It is proposed to act in conjunction with the New Zealand Institute, the Society of Chemical Industry, the Chemical Society of London, and the Society of Public Analysts, in the promotion of conferences and lectures.

*Imperial Grant In Research.*

The Empire Marketing Board has generously offered £2,000 per annum for five years to be expended in New Zealand on research into the problem of eradicating the blackberry and other noxious weed pests, on condition that the Government and the Cawthron Institute between them will assist with a like sum. The Marketing Board is further offering a similar sum for two years on similar terms for the investigation of mineral content of pastures. According to the Hon. Minister for Agriculture (Mr. Hawken) (*Auckland Weekly News*, 4th November, 1926) this splendid offer was chiefly brought about by Dr. Tillyard, of the Cawthron Institute. It is to be hoped that it will be promptly dealt with and ultimately accepted.

*Scientific Survey of the North Island Thermal District.*

The decision to establish the headquarters of the Maori Arts and Crafts Board at Rotorua with Mr. H. Hamilton as Secretary must be mentioned. There is now much scientific activity in this wonderful district, which is also a charming health and holiday resort. Commencing with a topographical survey, now approaching comple-

tion, under the Lands Department, followed by a soil survey under the Agricultural Department, which has also progressed considerably, the vulcanologist of the Geological Survey (Mr. Grange) is now at work, and no doubt intensive biological and geological surveys will follow, so that the motion passed years ago by the Institute, that:—  
“The Government be urged to undertake the preparation of a complete scientific report on the Thermal Regions of the North Island” (p. 625, vol. 47, *Trans. N.Z. Inst.*, 1914) is now progressing towards realisation.

The thermal and adjacent districts of the North Island are destined, I am convinced, to become one of the most densely settled of all New Zealand's undeveloped lands; the more light that science can bring to bear on this unique and fertile country, the quicker will be the response in settlement.

### *Library Matters.*

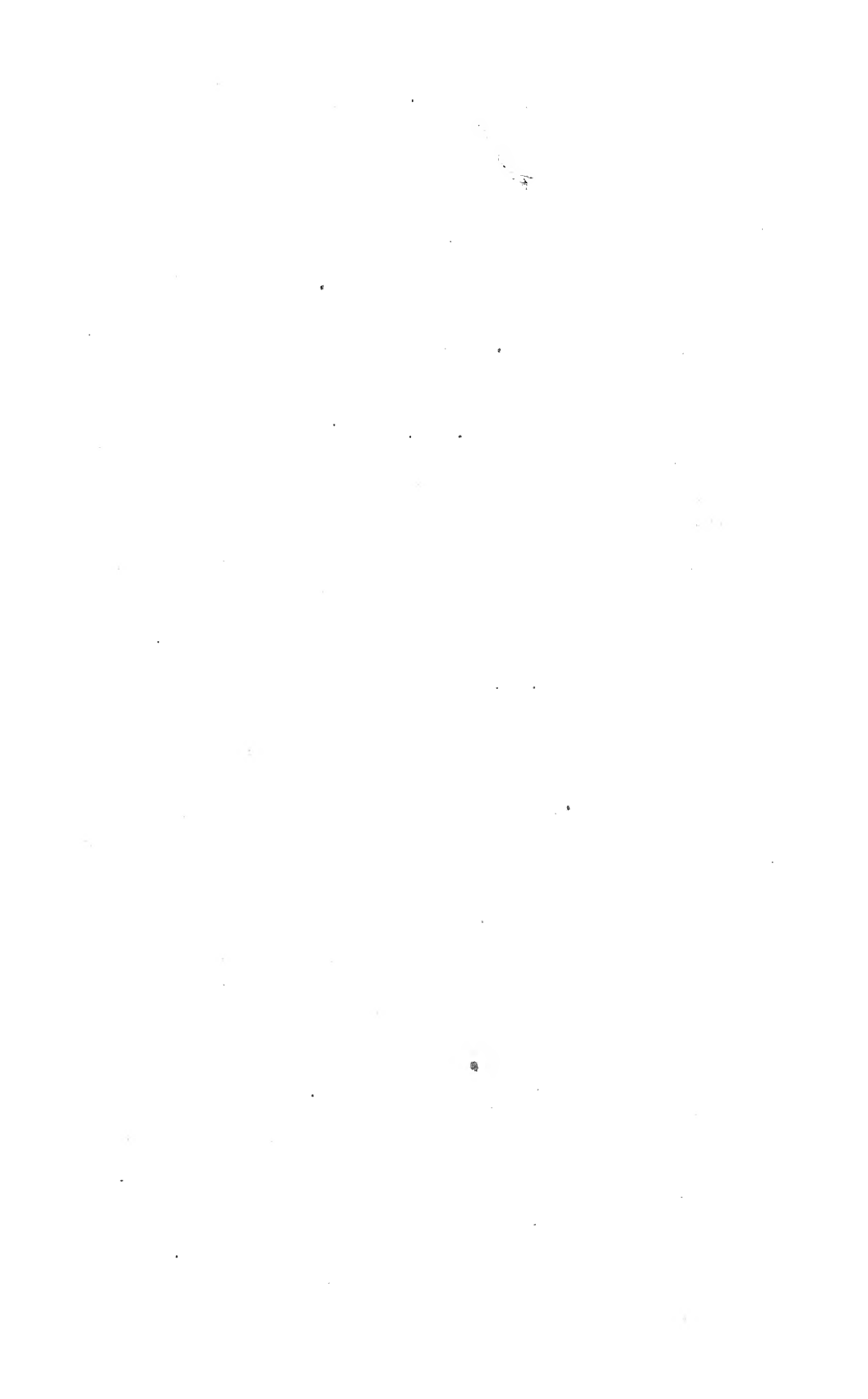
The Scientific Library of the Institute is rapidly growing, and the need for additional accommodation is giving some cause for anxiety. The Standing Committee reported to the last Annual Meeting that it had left the matter in the hands of Professor Kirk, and it is hoped that he will be able to induce the authorities to concede more room.

A body which has evolved in England as the outcome of increased activity in scientific matters is the Association of Special Libraries and Information Bureau (38 Bloomsbury Square, London, W.C. 1) which is about to become incorporated. I became acquainted with the organising secretary in London in 1925. The information he gave me may be consulted in the library. The object of the association is to assist members to get in touch with information buried in special libraries or otherwise difficult of access. The subscription is £2 2s. 0d. a year. The Institute might consider acquiring the above advantage for its members.

One notices that most of the scientific appointments recently are to comparatively young men, and the announcement has been made that no officer in the Government Service over sixty years of age will be promoted. One hopes much from youth, but a scientific life does much to keep the worker young, and the wisdom of experience is not to be despised. At a recent Chemical Society dinner in London, one of the speakers pointed out that Fellows of the Royal Society enjoyed an expectation of life 10.7 years longer than ordinary men. The moral is that we should all join the Royal Society. There are, however, difficulties in doing that; there is none in seeking to join the New Zealand Institute.



TRANSACTIONS.



# TRANSACTIONS OF THE NEW ZEALAND INSTITUTE.

## Fifth Supplement to the Uredinales and Ustilaginales of New Zealand.

By G. H. CUNNINGHAM.

Government Mycologist, Department of Agriculture, Wellington,  
New Zealand.

[Read before the Wellington Philosophical Society, 25th August, 1926;  
received by the Editor, 15th March, 1927; issued separately,  
4th August, 1927.]

Since the publication of the fourth Supplement, the following matter has come to hand.

### UREDINALES.

#### ADDITIONAL SPECIES.

UROMYCES DIANTHI (Persoon) Niessel, *Verh. Nat. Ver. Bruenn*, vol. 10, p. 162, 1872.

*Uredo Dianthi* Pers., *Syn. Meth. Fung.*, p. 222, 1801.

*Caeoma Dianthi* Link, Willd., *Sp. Pl.*, vol. 6, p. 26, 1825.

*Uromyces caryophyllinus* Wint., in Rabbh. *Krypt. Fl.*, vol. 1, p. 149, 1881.

*Nigredo caryophylla* (Schrank) Arth., *N. Am. Fl.*, vol. 7, p. 246, 1912.

II. Uredosori amphigenous, less frequently caulicolous, scattered, usually elliptical, bullate, soon naked and pulverulent, cinnamon-brown, often seated on pallid spots. Spores globose, ovate or elliptical, 20-28 x 20-26 mmm; episporium delicately and sparsely echinulate, 2.5-3 mmm thick, pallid brown, with 3-5 scattered, conspicuous, papillate germ-pores.

III. Teleutosori usually confluent, when elliptical, linear or circinate, pulverulent, dark brown, partly covered by the epidermis which is fissured longitudinally. Spores subglobose to shortly elliptical, 18-25 x 18-22 mmm; apex with a flattened hyaline papilla; base rounded; episporium densely and finely verruculose, 2.5-3 mmm thick; rich chestnut-brown; pedicel short, hyaline, deciduous; germ-pore apical, conspicuous.

Host: *Dianthus caryophyllinus* L. On leaves and stems. II-III. Napier, Hawke's Bay, May, 1926, *J. Anderson!*

Distribution: Europe; North America; Asia; South Africa; Australia; New Zealand.

In Europe this species is considered to be heteroecious, the aecidium occurring on *Euphorbia Gerardiana* Jacq.; but as there is some doubt as to whether the aecidium really occurs in the cycle, certain workers failing to infect *Dianthus* spp. with aecidiospores, a description of this stage is not given here.

The species is generally known as *Uromyces caryophyllinus* (Schrank) Wint., but as this specific name is taken from a publication antedating the starting point of modern nomenclature, it cannot be used; so Persoon's specific name *Dianthi* is used in its stead.

The teleutospores are usually described as being smooth, but are distinctly though finely verruculose under the oil immersion.

Mr. Anderson informs me that this has been a troublesome disease of carnations in his glasshouses for many years; yet strangely enough it has not been collected hitherto.

#### UREDOSPORIUM SCARIOSUS (Berkeley) n. comb.

*Uromyces scariousus* Berk., *Fl. N.Z.*, vol. 2, p. 195, 1855.

II. Uredosori hypophyllous and on petioles, sparse, scattered, orbicular or lenticular, up to 2 mm. diam., usually less, pulverulent, ferruginous, seated on pallid spots, surrounded by the ruptured epidermis. Spores subglobose, ovate or elliptical, 24-30 x 22-26  $\mu$ m; epispore pallid chestnut, 3  $\mu$ m thick, finely and sparsely echinulate, spines about 3  $\mu$ m apart, with two equatorial, conspicuous germ-pores.

Host: *Geranium dissectum* L. On leaves and petioles. Day's Bay, Wellington, Apl. 1925, E. H. Atkinson!

This species was described originally by Berkeley from *Geranium dissectum* and *G. microphyllum* Hook. f. (= *G. potentilloides* Hook f.) collected in Hawke's Bay by Colenso. The abundant collections brought in by Mr. Atkinson show abundance of uredospores, but no teleutospores. Berkeley's description could equally well be applied to these, consequently until teleutospores are found the species will be considered as an *Uredo*.

#### ADDITIONAL HOSTS.

HAMASPORIA ACUTISSIMA Syd. (*Trans. N.Z. Inst.*, vol. 55, p. 22, 1924).

Host: *Rubus Schmidelioides* x *australis*. Feilding, Wellington, Oct. 1926. H. H. Allan!

Dr. Allan informs me that he has noted this rust only on this hybrid, and not on true *R. australis*. That such is not always the case, however, is evident from the fact that several of the collections in my herbarium are on *R. australis*.

#### *Melampsora Lini* Desm. (l.c., p. 27).

*Linum usitatissimum* L. On leaves and stems. Canterbury, Jan., 1926, F. E. Ward!

This is the first time that this rust has been collected in New Zealand on cultivated linseed. But now that this host is being so widely grown (12,000 acres being sown in Canterbury last season) it may prove a troublesome disease.

*Puccinia coronata* Cda. (*Ibid.*, vol. 54, p. 641.)

Host: *Holcus mollis* L. On leaves. Highbank, Methven, Canterbury, Mar., 1927, A. H. Cockayne!

Corrections.

*Puccinia tasmanica* Diet. (l.c., p. 689.)

Syn.: *P. Erechitis* McAlp., *Proc. Roy. Soc. Vic.*, vol. 7, p. 216, 1894.

As the result of the examination of numerous recent collections of "*Puccinia Erechitis* McAlp." on *Erechtites prenanthoides* (A. Rich.) DC. I can now find no difference between this form on this host and *Puccinia tasmanica* on *Senecio vulgaris*. Consequently I am of the opinion this is but a synonym of *P. tasmanica* Diet.

*Puccinia Pelargonii-zonalis* Doidge, *Bothalia*, vol. 2, p. 98, 1926.

Mis. det.: *P. granularis* Kalkh. et Cke.

In a former paper (*Trans. N.Z. Inst.*, vol. 54, p. 659, 1923) *Puccinia granularis* was recorded as occurring on *Pelargonium zonale* l'Herit. In a recent monograph on the rusts of South Africa Dr. Doidge has shown that the rust on *Pelargonium zonale* is not *P. granularis*, the type of which occurs in South Africa, but is a species which was found to be underscribed and accordingly named *P. Pelargonii-zonalis* Doidge. This name should therefore replace that of *P. granularis* for the species on this host. It is separated from *P. granularis*, which is confined to South Africa, in that no aecidium occurs in the cycle, and in the thinner wall of the uredospore (2–2.5 mm), that of the former species being 3–3.5 mm.

Dr. Doidge states that *Puccinia Morrisoni* McAlp. (on *Pelargonium inodorum* Willd.) is a very closely related species and questions whether it is distinct from *P. granularis*. I have compared specimens of these two species and find that the uredospores serve to separate them, those of *P. Morrisoni* differing in their usually ovate shape, much thinner wall (2 mm), and smaller germ-pores. In other respects they are very similar.

*Puccinia ruizensis* Eug. Mayor, *Mem. de la Soc. neuchateloise des Sci. Nat.*, vol. 5, p. 486, 1913.

Syn.: *P. Oreomyrrhidis* G. H. Cum., *Trans. N.Z. Inst.*, vol. 54, p. 669, 1923.

Dr. Eug. Mayor has drawn my attention to the fact that in his "Uredinees de Colombie" (l.c.) he has previously described as *P. ruizensis* a species on *Oreomyrrhis andicola* (H.B.K.) Endl. which he considered the same as the rust I had named *P. Oreomyrrhidis*. He has kindly forwarded type material which on comparison I find closely resembles the New Zealand form. While there are certain points of difference these are not sufficient to enable separation to be effected, consequently *P. Oreomyrrhidis* must be considered as a synonym of *P. ruizensis*.

I am indebted to Dr. Mayor for calling my attention to this matter, for the donation of type material of *P. ruizensis*, and for a copy of his monograph "Uredinees de Colombia."

The locality, Colombia, South America, should be added to the distribution of this species.

## USTILAGINALES.

### *Additional Host.*

*Ustilago bullata* Berk. (Ibid., vol. 55, p. 413).

Host: *Agropyron scabrum* (Lab.) Beauv. Hawarden, Canterbury, Jan. 1925, *F. E. Ward*; *G.H.C.* Seddon, Marlborough, Dec. 1926, *J. C. Neill*; *G.H.C.*

This smut is abundant on this grass on roadsides throughout these districts. Hitherto it has been collected in New Zealand only by Colenso, so that my published description was drawn up from Australian material.

### *Correction.*

*Ustilago Kolleri* Wille, *Bot. Notiser*, p. 3, 1893.

Syn.: *U. levis* Magn.

This species was first separated as the variety *levis* from *Ustilago Avenae* by Kellerman and Swingle (*Second. Rept. Kansas State Agr. Coll.* for 1889, p. 259, 1890); in 1896 Magnus (*Abh. Bot. Ver. Prov. Brand.*, vol. 37, p. 69, 1896) raised it to specific rank. Wille (*l.c.*) independently named it *U. Kolleri*. This name was the first given to the plant as a species, *levis* being but the name of a variety. Therefore in accordance with Article 49 of the International Rules of Botanical Nomenclature the name for this species must be *Ustilago Kolleri*, as the combination *U. levis* (Kell. et Sw.) Magn. was proposed at a later date.

I am indebted to Dr. G. H. Pethybridge, Mycologist, Ministry of Agriculture and Fisheries, England, for supplying me with particulars as to the correct name for this smut.

## An Artificial Rubus Hybrid.

By H. H. ALLAN.

[Read before the Canterbury Philosophical Institute, 1st September, 1926;  
received by Editor, 4th October, 1926; issued separately,  
4th August, 1927.]

WHEN describing *Rubus Barkeri* from a single plant discovered by the late Mr. S. D. Barker at Inchbonny, Westland, Cockayne (1910, p. 325) stated:—

“Possibly the species under consideration is a recent break from *R. parvus*, the new characters having originated by mutation. Equally possible is the chance of its being a hybrid between one or other of the species of *Rubus*, especially *R. australis* and *R. parvus*, though this view is somewhat discounted by the non-climbing habit.” Later Cockayne (1923, p. 125) lists *R. Barkeri*, without query, as being *R. australis* x *parvus*. To gain further light on the matter I decided to endeavour to secure hybrids by artificial cross-pollination.

A female plant of *R. parvus* was secured from the Wangapeka Valley (North-western Botanical District). The plant was gathered from a colony showing no signs of hybridism among its members. This was grown in Feilding in a position isolated from all other *Rubus* plants, and there was no other *R. parvus* grown in the neighbourhood. The plant was observed for four flowering seasons, during which it grew vigorously, and flowered freely. In no season was there any sign whatever of fruit-setting, the flowers simply withering up and falling away. The possibilities of accidental pollination, or of parthenogenesis thus seemed to be eliminated. A number of young flower-buds were protected from accidental pollination, and on opening were pollinated by hand in November, 1924. In all the flowers operated on, some achenes developed, while others failed to do so, apparently not having received the pollen. All the untreated flowers, as before, entirely failed to produce any development of the achenes. As pollen from *R. australis* was not available *R. schmidelioides* was used as the male parent, the pollen (all from one plant) being applied within an hour of gathering by means of a fine brush. Difficulty was experienced in obtaining a sufficient supply of pollen, and a certain percentage of that used was probably immature, which, in part, may account for the number of unfertilized achenes. Some 30 achenes were secured, and were sown on December 10th, 1924, being then almost ripe. Unfortunately three of the seed-pans were accidentally destroyed, but from the remaining one six healthy hybrid plants have been obtained. The seedlings appeared above ground between the 15th and the 20th October, 1925, and are thus now just one year old.

When large enough to handle, the plants were transplanted to small pots, which were plunged in a shady part of the garden. In May, 1926, the plants were placed in an open border. Some trouble was experienced with aphid infestation, one plant particularly being stunted and somewhat deformed. All are now (October, 1926), how-

ever, healthy, and commencing to make vigorous growth. The main stems are about 12 cm. long, of trailing habit, with a tendency to ascend, but at present showing no signs of adventitious rooting. Side stems are developing from near the bases of the main stems, and the stunted plant has a somewhat bushy habit.

### DESCRIPTION OF THE HYBRID SEEDLINGS.

**COTYLEDONS.**—Oblong-orbicular, ciliated with fine glandular hairs, thin, pale-green,  $\pm 4$  mm. long by  $\pm 5$  mm. broad, flat or slightly concave above, persisting till third or fourth leaf is developed.

**FIRST LEAVES.**—Broadly ovate, serrate, ciliate as in cotyledons, bearing also scattered fine, pale hairs on both surfaces; petioles short, slender, ciliated; blades  $\pm 5.5$  mm. long by  $\pm 5$  mm. broad, pale green to yellowish, with reddish veins, both surfaces bearing scattered pale hairs.

**SECOND LEAVES.**—Similar to first, but rather larger and subacute, less hairy above, glabrate below, petioles slender, longer, glandular-hairy.

**THIRD LEAVES.**—Ovate-oblong, subacute, deeply and coarsely serrate-dentate, midrib very evident below, surfaces as in second leaves, hairs caducous; blades  $\pm 2$  cm. long by  $\pm 12$  mm. broad; petioles as in second leaves, but hairs soon disappearing.

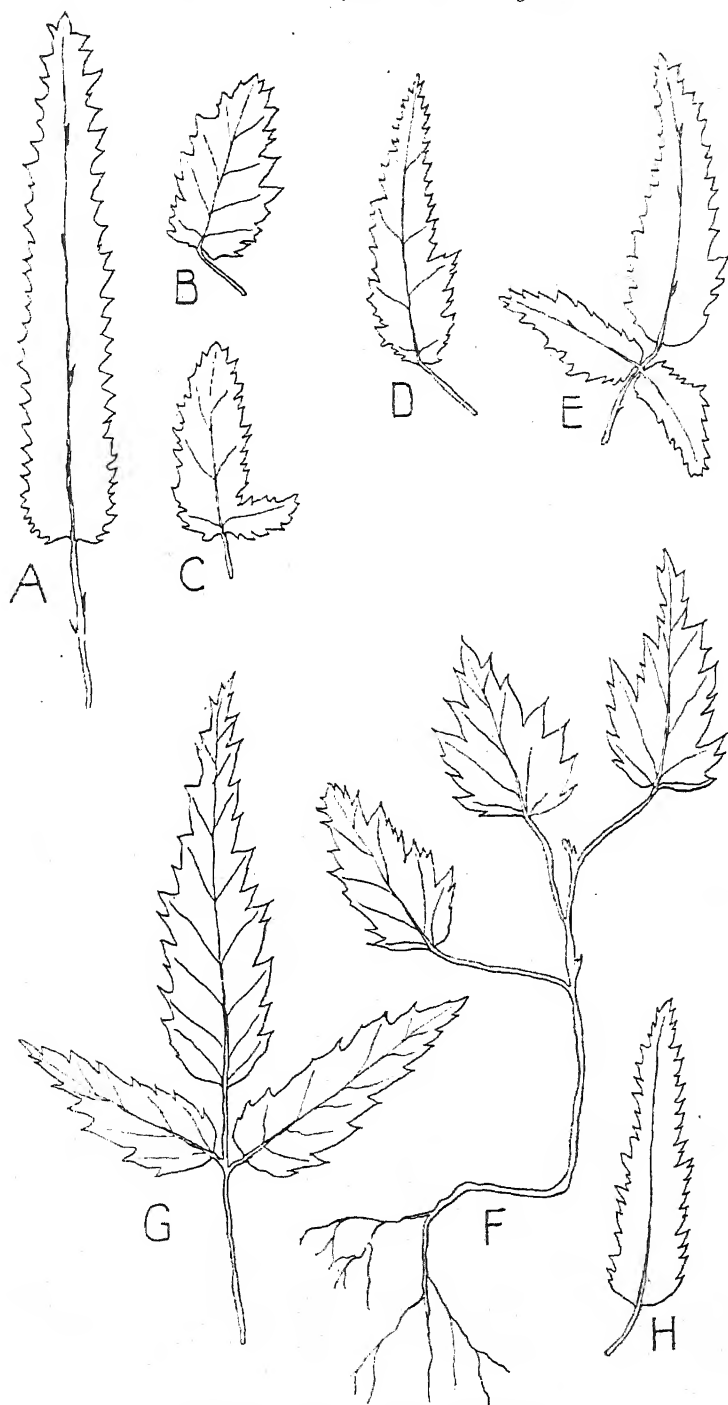
**FOURTH LEAVES.**—Similar to third leaves, but longer, more acuminate, slightly more coriaceous, sometimes more or less deeply lobed, in one case almost trifoliate, darker green, becoming bronzed in winter.

**SUBSEQUENT LEAVES.**—Coriaceous, mainly trifoliate, sometimes bifoliate or merely deeply lobed, bronzed in winter, pubescent when young, becoming glabrate when mature; petioles  $\pm 2.2$  cm. long; terminal leaflets  $\pm 5$  cm. long by  $\pm 1$  cm. broad, on very short petiolules, linear-oblong, acute or acuminate, dentate; lateral leaflets  $\pm 1.4$  cm. long, similar in shape to terminal; midribs and occasionally the petioles and petiolules bearing a few small, rather stout prickles. The first leaves to develop this spring were again unifoliate and similar to the third and fourth leaves of the first season, the succeeding leaves are bi- or trifoliate.

### SEEDLINGS OF THE PARENTS.

I have at present no seedling material of *R. parvus*, but give a description of seedlings of *R. schmidelioides* grown at the same time as, and under similar conditions to those of the hybrids. The achenes were gathered from a plant similar in character to that used

- 
- A *Rubus parvus* adult leaf.
  - B Second leaf of hybrid.
  - C, D, H. Fourth leaves of hybrids.
  - E Trifoliate leaf of hybrid
  - F Seedling *R. schmidelioides*, showing first, second and third leaves.
  - G Trifoliate leaf of seedling *R. schmidelioides*.



LEAVES OF RUBUS—Natural Size.

as pollen parent, and growing in an association where *R. australis* was absent.

COTYLEDONS.—Very similar to those of the hybrid, but narrower, oblong.

FIRST LEAVES.—Petioles  $\pm$  1.3 cm. long, slender, densely clothed in pale brown hairs; blades ovate, acuminate, deeply and coarsely irregularly serrate, very thin, clad above and on the margins with numerous pale brown hairs, glabrate below, midrib densely hairy above, not prominent below.

SECOND AND THIRD LEAVES.—Similar, but larger,  $\pm$  3 cm. long by 1.5 cm. broad.

FOURTH LEAVES.—Trifoliolate, similar in character to others; terminal leaflet  $\pm$  2.6 cm. long by  $\pm$  1.4 cm. broad, with petiolules  $\pm$  .75 cm. long; lateral leaflets smaller; all leaflets ovate, acute or acuminate.

SUBSEQUENT LEAVES.—Similar, but leaflets longer and narrower.

A fuller description will be published later when the hybrid plants become more mature, and a comparison made between the adult forms. I intend this season to pollinate *R. parvus* with pollen from the form of *R. australis* occurring near Feilding. It will be seen from the above account that the hybrids resemble *R. schmidelioides* in producing trifoliolate leaves, but more closely approach the female parent in the more coriaceous texture of the leaves, their more nearly dentate toothings, their narrower shape, the presence of prickles on the midribs, the lesser development of hairs on the young stems, leaf-stalks and midribs. *Rubus Barkeri*, which occasionally produces unifoliolate leaves, parallels these features, and I have little doubt that the hybrid theory as to its origin is the correct one; var. *coloratus* of *R. schmidelioides* is referred to throughout.

#### LITERATURE CITED.

- COCKAYNE, L., 1910. "On a Non-flowering New Zealand Species of *Rubus*." *Trans. N.Z. Inst.*, vol. 42, p. 325.  
COCKAYNE, L., 1923. "Hybridism in the New Zealand Flora." *New Phytol.*, vol. 22, p. 105.

## The Vegetation of Awarua Plain.

By J. CROSBY SMITH.

[Read before the Otago Institute, 9th November, 1926; received by Editor, 27th November, 1926; issued separately, 4th August, 1927.]  
(Plate 1.)

WHAT is known as Awarua Plain is a swampy bog covering many thousand acres. The Invercargill-Bluff railway runs through it on the western side for probably ten miles of its length. The depth of peat shows it to have been a large lagoon formed probably by the sinking of the land and the blocking up by sand dunes at the south-eastern end. The under stratum is white quartz gravel deposited by a large river which once flowed over the Southland plain. The depth of peat is five to six feet. From ditches cut for drainage can be seen stumps of a previous generation of Manuka. These are 18 inches below the present surface, some of which are 10 inches in diameter.

This swampy-bog is only a few feet above sea level, and is possibly unique in the South Island, at least in being occupied largely by subalpine plants similar to those of Southern Southland and Stewart Island. As it is now being drained and put under cultivation, I consider some record should be made of its ecological character before it is too late.

My notes of the plants growing there now and in the immediate past were made twelve years ago, before the draining had made great effect on the original vegetation. From a recent visit I find that the water has been so far drawn off that the surface has sunk in places 18 inches, leaving the cushion-plants high and dry, with the result that they are dying rapidly. Other plants depending on very damp conditions such as *Utricularia monanthos* have mostly disappeared.

The wettest parts of Awarua swampy-bog are occupied by various species of *Sphagnum*, *Oreobulus pectinatus*, *Oreostylidium subulatum*, *Drosera spatulata*, *D. binata*, *Montia fontana*, *Elatine americana*, *Var. australiensis*, and some *Microlaena Thomsoni*.

On drier ground *Donatia novae zealandiae* forms large cushions 4 feet long by 3 feet wide and 2 feet high (fig. 1). On nearly all these cushions *Pentachondra pumila* or *Cyathodes pumila* flourish as epiphytes. In addition, on this drier ground are *Gaultheria depressa*, *Pernettya nana*, *Leucopogon Fraseri*, *Dracophyllum longifolium*, and *Gunnera albiflora*.

On the upper and still drier ground *Phormium tenax* flourishes, and is now 6 or 7 feet in height. This is quite different from that species at the lower end of the swamp on the west of the Bluff railway line, which is stunted to 3 feet in height. *Leptospermum scoparium* behaves similarly (fig. 2), and on the drier ground is 8 feet high, while in the more damp places it is only 2 to 3 feet high. It is interesting to note that along most of the ditches, which are 5 feet deep, *L. scoparium* has taken a hold 15 inches down the sides of the ditch where it is dry, and is growing freely.

Where the ground is nearly at its maximum dryness *Danthonia Raoultii* var. *rubra* 5½ feet high has taken a good hold, and is now covering acres.

Except *Gleichenia circinata* and *G. dicarpa*, *Lindsaya linearis*, and *Schizaea fistulosa*, the other ferns do not grow far from the ditches. *Hypolaena lateriflora* fills up a good deal of space between the cushion plants. A number of other plants not mentioned above are found on the fringes of the swampy-bog in places that have been dry for some time.

# LIST OF SPECIES OF THE AWARUA PLAIN.

## FILICES.

*Lindsaya linearis*.  
*Pteridium esculentum*.  
*Histiopteris incisa*.  
*Blechnum praeurum*.  
 — *Banksii*.  
*Polystichum vestitum*.  
*Schizaea fistulosa*.  
*Gleichenia circinata* var. *Alpina*.  
 — *microphylla*.  
*Ophioglossum pedunculatum*.

## LYCOPODIACEAE.

*Lycopodium volubile*.  
 — *ramulosum*.

## GRAMINEAE.

*Poa Colensoi*.  
*Danthonia Raoulii* var. *rubra*.  
 — *semianularis*.  
*Microlaena Thomsoni*.

## CYPERACEAE.

*Cyperus alpina*.  
*Oreobolus pectinatus*.

## RESTIONACEAE.

*Hypolaena lateriflora*.  
*Leptocarpus simplex*.

## JUNCACEAE.

*Juncus lampocarpus*.

## LILIACEAE.

*Astelia Cockaynei*.  
*Phormium tenax*.  
*Herpotion novae zelandiae*.

## IRIDACEAE.

*Libertia irioides*.

## ORCHIDACEAE.

*Prasophyllum Colensoi*.  
*Thelymitra longifolium*.  
 — *uniflora*.

## PORTULACACEAE.

*Montia fontana*.

## DROSERACEAE.

*Drosera binata*.  
 — *spathulata*.

## ROSACEAE.

*Acaena sanguisorbae*.  
 — *microphylla*.

## RHAMNACEAE.

*Discaria toumatou*.

## ELATINACEAE.

*Elatine americana* var. *australiensis*.

## VIOLACEAE.

*Viola Cunninghamii*.  
 — *filiculae*.

## THYMELAEACEAE.

*Pimelea prostrata*.

## MYRTACEAE.

*Leptospermum scoparium*.

## ONAGRACEAE.

*Epilobium nerterioides*.

## HALORAGIDACEAE.

*Halorrhagis uniflora*.  
*Gunnera albocarpa*.  
 — *prorepens*.

## ERICACEAE.

*Gaultheria perplexa*.  
 — *depressa*.  
*Pernettya nana*.

## EPACRIDACEAE.

*Pentachondra pumila*.  
*Cyathodes empetrifolia*.  
 — *pumila*.  
*Leucopogon Fraseri*.  
*Dracophyllum longifolium*.

## LENTIBULARIACEAE.

*Utricularia monanthos*.

## GENTIANACEAE.

*Gentiana lineata*.

## STYLIDACEAE.

*Donatia novae-zelandiae*.  
*Oreostyidium subulatum*.

## COMPOSITAE.

*Helichrysum bellidioides*.  
*Cassinia vauvilliersii*.  
 — *fulvida*.  
*Celmisia gracilentia*.  
*Gnaphalium luteo-album*.

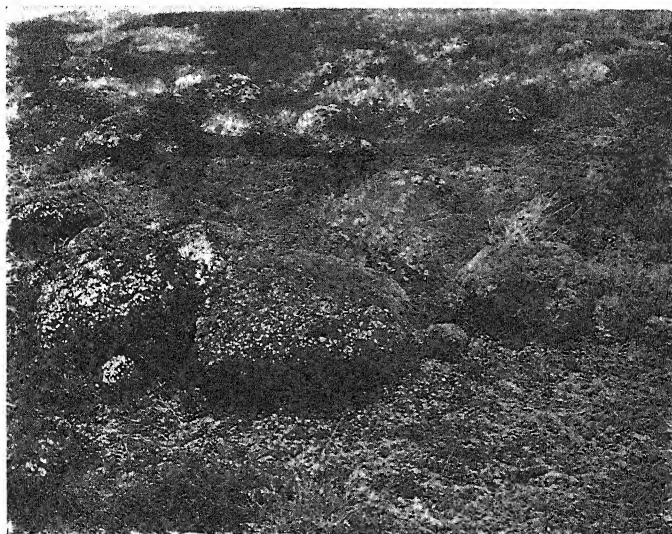


FIG. 1.—Cushions of *Donatia novae zelandiae* in flower on Awarua Bog, intermixed with sphagnum moss.



FIG. 2.—Dwarf area of manuka (*Leptospermum scoparium*) on Awarua swamp land.



## Observations on *Corynocarpus laevigata* Forst, the karaka.

By ELLEN PIGOTT, M.A.

[Read before the Wellington Philosophical Society, 25th May, 1927;  
received by Editor 26th May, 1927; issued separately  
4th August, 1927.]

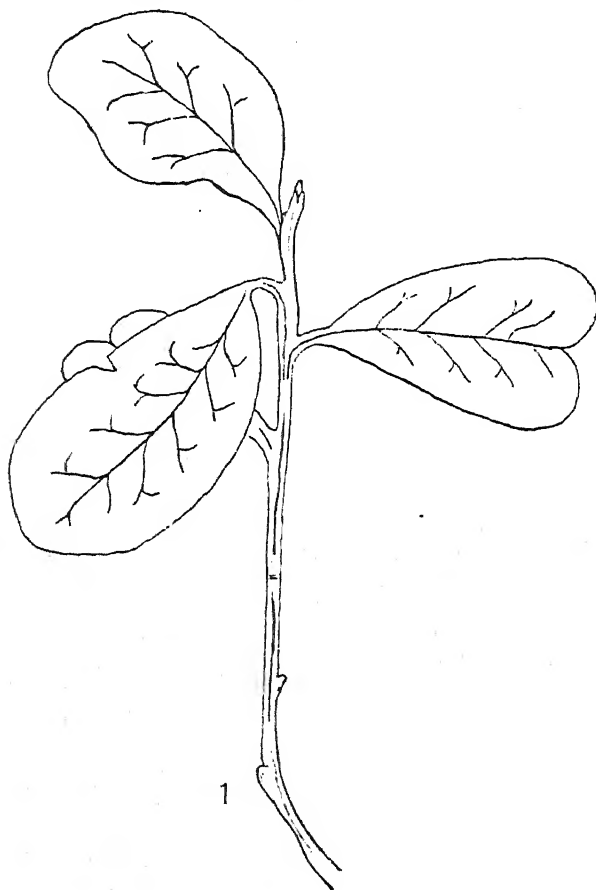
IN the *Manual of New Zealand Flora*, 1906, p. 104, Cheeseman places the genus *Corynocarpus* in the family Anacardiaceae, at the same time noting that Professor Engler considers *Corynocarpus* to be the type of a new family to which he gives the name Corynocarpaceae, which Cheesman uses in the second edition of the *Manual*. Hemsley (*Annals of Botany*, September, 1903) confirms Professor Engler's statement regarding the total absence of resin-canals which are present in all other genera of the Anacardiaceae but one, *Juliania*, but considers that this peculiarity is not accompanied by correlated characters of sufficient importance to justify the exclusion of the genus from the family. Boodle and Frittsch (*Comparative Anatomy of Dicotyledons*, p. 244-248) state that the genus should be excluded from the family solely because of the absence of resin-canals in the root, stem, and leaf.

Among characters of the family Anacardiaceae are the absence of stipules, and the presence on the leaves of some species belonging to certain genera either of peculiar glandular uniseriate hairs or of multicellular branched trichomes. Since these vary much in shape, it has been suggested that possibly they furnish useful characters for the distinction of species. They all occur on the under-surface of the leaves. Engler says it is not uncommon to find simple unicellular hairs; also, uniseriate *clothing* hairs with pointed or blunt ends occur in the Anacardiaceae. Other characters of the family are found in the flower and fruit; for example, the number of carpels and of ovules is reduced, the anthers are two-celled, and the seeds have no endosperm. (The genus *Corynocarpus* has four-celled anthers). Regarding the genus, Boodle and Frittsch state that three fibro-vascular bundles pass into the leaf and of these three the median bundle divides into five which form an arc open on its upper side. The flowers are discussed by Kirk in the *Forest Flora of New Zealand*, where he states that in the genus *Corynocarpus* the "stamens are inserted between the lobes of an annular disc." The lobes are swollen and fleshy and each is tipped with a narrow, jagged petal-like process. Cheeseman calls these lobes staminodia.

*Corynocarpus laevigata*, the karaka, is one of our tall forest trees which does not extend much farther south than Latitude 40° S. A full account of its origin and distribution is given in Cheeseman's illustrated work on the New Zealand Flora. The trees are very slow

growing and are several years old before they begin to bear flowers. Even so, the effort seems to be too much, for it is quite a common thing for trees to rest a season and bear no flowers. Also, trees growing close to the shore usually blossom earlier than trees growing a few miles inland.

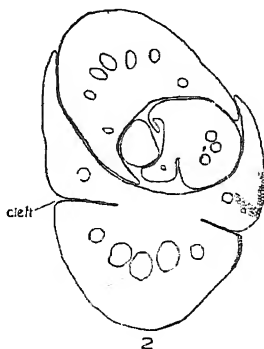
*Leaves.*—The young seedlings bear leaves of a full adult size, each leaf, however, with one notch at the apex (Fig. 1). This seems to be a slight approach to the heterophylly exhibited by so many of our New Zealand plants. The apex of the adult leaf is sub-acute,



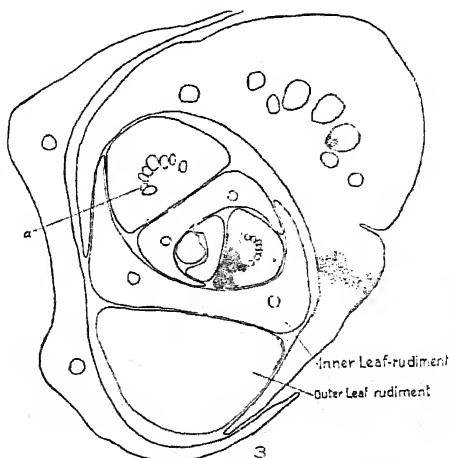
almost rounded, as seen in Fig. 1, where a seedling is shown bearing two juvenile and two adult leaves. All leaves when fully grown are dark green, smooth, and glabrous, possessing on both surfaces numerous small depressions like pin-pricks. The young leaves in the bud are very interesting, and a description of their development follows.

The young stem shows at the apex typical stem structure. A very large number of vascular bundles is present. The young leaves

which cover the growing point have thick bases which ensheath about two-thirds of the circumference of the stem, and a leaf base in its lowest part where its cells are indistinguishable from the cells of the stem contains already the three fibro-vascular strands which are described by Boodle and Fritzsche as being characteristic of the genus. They are large strands and connect directly with the stem stele. As the blade of each leaf-rudiment becomes separated from the stem it always happens that one margin becomes separated earlier than the other, and if the leaves are considered in the order of their development along the genetic spiral it is always the margin that on a conventional genetic spiral would be the nearer to the apex that separates



first. The median bundle divides into five and the developing leaf-rudiments show the seven bundles which are characteristic of the genus arranged in horseshoe shape. The "blades" of the leaf-rudiments are not expanded like laminae generally, but are prismatic, with three sides (Fig. 2), and if these blades are examined they are found to possess on their upper surfaces curious hairs, but none on



A Cross Section of a Vegetative Bud.  
At *a* one of the extreme fibro vascular bundles is dividing again.

their lower surfaces. As development goes on the prismatic shape becomes less evident, and at the same time there develop on the convex lower surface two indentations or clefts (Figs. 2 and 3). These clefts become carried towards each other parallel to the upper surface with the result that the blade splits into two halves, an inner and an outer. It so happens that the inner half has the two extreme fibro-vascular bundles, one near each end, and these two bundles are two of the three bundles which passed out originally from the stem and which never divided. This inner half is flattened like a lamina, but it has a narrow region along the middle, where there is no fibro-vascular strand. Its widest portions are where the fibro-vascular strands lie (Fig. 3), and it possesses so far all the hairs. The outer half is prismatic, in cross section triangular, with two abaxial short sides, and the long adaxial side adjacent to the abaxial side of the inner half leaf-rudiment from which it was split off (Fig. 3).

After this stage in development the inner half develops no more hairs, both halves increase and grow in length at the same rate until they reach a length of a centimetre or more, and a young shoot now presents the appearance of having two leaves inserted together on the stem (at the same spot), one inside the other. The inner portion is almost transparent. Its development is arrested, and it never grows much longer than one centimetre, and often less. When it was first formed by splitting of the rudiment it possessed all its cells each of which increased in size until the maximum was attained, in the process losing the chlorophyll and protoplasm. When fully grown it becomes reddish-brown and membranous, consisting of dead cells and serving as a scale. It has a function, and that is to protect the bud-leaves next inside, and these it completely enfolds.

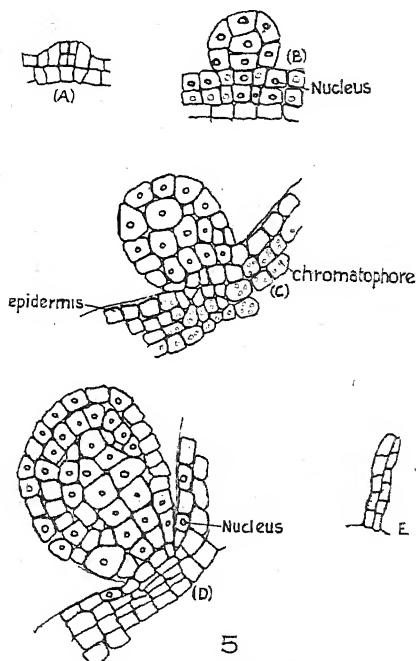
The development of these scales suggests the formation of connate stipules, and in an adult stem they are visible as small scales in the leaf-axil closely adpressed to the stem. Their function is done.



Transverse section of a young leaf in the bud.

The outer prismatic half of the leaf-rudiment develops into the foliage-leaf. Hairs develop on both sides in large numbers (Fig. 4), while the leaf is still prismatic and while all its cells are actively dividing. All these hairs, however, die before the leaf is fully expanded. It has been suggested by Boodle and Fritzsch (*Comparative Anatomy of Dicotyledons*, p. 245) that since in the different species of *Rhus* the hairs are variously shaped, they might furnish

useful characters for specific distinction. According to them, among the many species investigated, two alone, *R. acuminata*, D.C., and *R. semialata*, Murray, possess papillae on the lower surface of the leaf. As regards the genus *Corynocarpus* no mention is made of any hairs. In *Corynocarpus* the hairs vary among themselves. As has been stated, they occur on the adaxial surface of the scale, and on both surfaces of the leaf-rudiment, early in development; also they vary in shape (Fig. 5, b, c, d). On the scale they take the form of double rows of cells with pointed or blunt ends (Fig. 5, e), or sometimes they may be club-shaped outgrowths. On the leaf itself they are in almost every case globular. They occur in large numbers but are never so crowded as on the leaf-base. When first formed, in



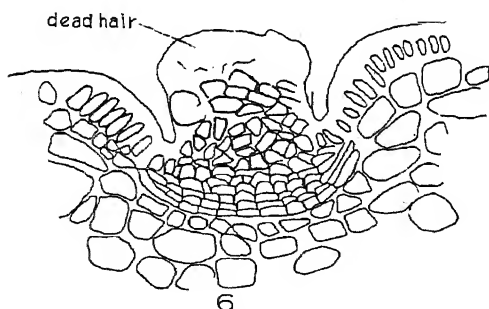
A Vertical Section through a hair.

proportion to the size of the little leaf they are very large, and their development is completed long before the leaf unfolds. The uniseriate outgrowths and unicellular hairs found in some species belonging to the family do not occur in the karaka. The dense crowding of hairs on the scale may in part account for their being elongated; it may possibly also, in the first place, influence the direction of the dividing walls. In both leaf and scale a hair arises from one (or sometimes two) epidermal cells. The cell (or cells) becomes slightly larger than its neighbours, then divides in planes almost perpendicular to the leaf-surface, so that a small group of cells is formed which projects slightly above the epidermis. The direction of the first dividing walls is not constant; it may vary from

almost perpendicular to very oblique, also the number of epidermal cells that take part in the formation of a hair may be more than two. The next dividing walls are at right angles to the first, and a small rounded outgrowth on the surface of the leaf is the result (Fig. 5, a). Further divisions take place irregularly as the hairs increase in size, so that the hairs are not all the same shape (Fig. 5, b, c, d.).

While a globular hair is developing a disturbance takes place in the hypodermal tissue. The cells surrounding the hair and at its base become drawn up into a convex shape, and it would seem that they enter into and take part in the formation of the hair. However, this is only apparent. The hypodermal cells take no part in the development of hairs.

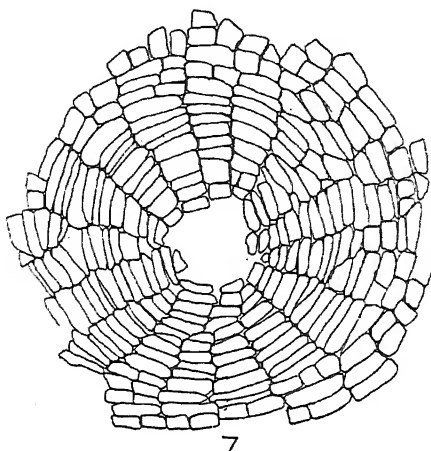
A description of the leaf-anatomy is given by Hemsley (*Annals of Botany*, September, 1903), but he makes no mention of any hairs. He describes a 1 to 2-layered hypoderm just beneath the epidermis, and mentions that "cork-warts occur in small numbers on the lower epidermis." It seems that these cork-warts are formed by dead hairs, for as soon as the hairs are fully grown they begin to die off, first becoming golden brown. By this time the leaves begin to assume their characteristic dark green colour. The cells of the hairs collapse, as do also the cells of the convex hypodermal group, and the cells of the epidermis lying above them. This causes the outline of the epidermis to fall in just at that point and the hairs come to lie each in a depression, whose entrance they block (Fig. 6). In



A depression on the leaf surface.

many cases the hairs drop out altogether, leaving minute holes like pin-pricks. The layers of cells forming the floor of a pit were once the hypodermal cells, and they are arranged very regularly, after the fashion of cork cells (seen in section). They consist of either cutin or suberin and together with the cuticle stain the same shade of yellow with chlor-zinc-iodine, and the same different yellow with potash. They are more or less soluble in concentrated sulphuric acid. The dead hairs form the cork-warts. This formation of pits applies to the leaf alone, for on the leaf-scales the formation of hairs causes no convex swellings or subsequent depressions. When the time comes the hairs die and drop off, leaving no mark.

A marked peculiarity is found in the epidermal cells surrounding a hair. If strips are taken from the epidermis, these cells are seen to be arranged concentrically and radially, and there are very many concentric circles of cells. This arrangement of cells is so obvious in a surface view that it is difficult to understand why it should have been so long overlooked. In this concentric arrangement the hypodermal cells take no part (Fig. 7).



Surface view of a leaf depression.

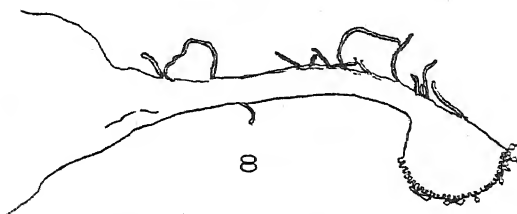
The hairs seem, therefore, to have no special function. In the leaf-scale they may be slightly protective, for it is only there that they are in any way a covering, but even on the scale they are not present except in the bud, and on the leaves they are completely protected by the leaf-scales immediately outside them. It was not determined whether the hairs are absorbent or otherwise. Very thick sections possessing whole hairs were taken, and placed in eosin. They were left in some cases for three days, but at the end of the time, although the sections were deeply stained everywhere else, the hairs remained colourless, except that in one or two cases the eosin entered a hair from its base.

Hemsley notes the large numbers of clustered crystals in the plant. They are calcium oxalate and occur in all parts, even in the petals. Schimper says that calcium oxalate formation in leaves is connected with the appearance of old age, but in the karaka the crystals are abundant in even the youngest leaves, also in all parts of the flower.

*Flower*.—The flower-buds are very slow in development, so that from the time the buds first appear, in June and July, it is some months before the flowers open, in late September and October. In very small buds, 1 mm. in diameter, the ovary is fully formed and the carpels have closed in. The buds increase to a diameter of 3 mm. and then open; the flowers are 5 mm. across and pale green. The style in buds of 1 mm. diameter is very short, the stigma colour-

less, and bent at right angles to the style. The anthers are as tall as the gynoeceum with very short thick filaments. The stigma slowly develops a bright red colouring matter while still in the bud, but as soon as the flowers open the red pales to yellow. The anthers dehisce almost as soon as the flowers open. The style remains always short with the stigma bent. The ovary is one-celled and swollen on one side, and on this side the ovule is inserted.

*Pollination.*—The five anthers are introrse, and the stigma exposes its stigmatic surface about the same time as the anthers dehisce. Bees and blowflies visit the flowers when the days are not too windy, and probe right down to the base. However, it seems probable that the flowers are wind-pollinated, for compared with the enormous number of flowers produced, the amount of seed set is very small, and it is not at all an unlikely thing to find no fruit on trees which were covered with blossom. Pollen-grains lodged on the stigma germinate in large numbers almost immediately, penetrating the

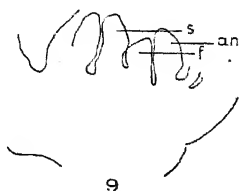


The style is split, showing pollen tubes.

style like hyphae, almost to the base (Fig. 8), but some weeks seem to elapse before fertilization takes place. This may partly be the reason why seed so often fails to set, and the prevalent gales at this time of the year, November, which blow almost all the flowers from the trees may account for the rest. If a flower is allowed to remain on the trees for some time after pollination but before the pollen tubes reach the ovary the pedicel withers and the flowers snap off at a touch.

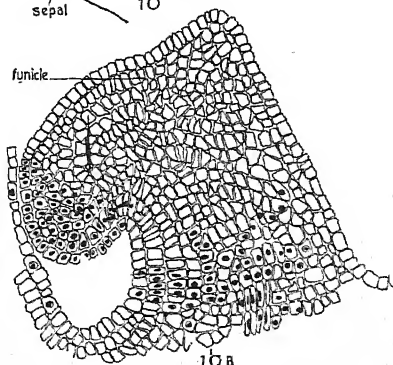
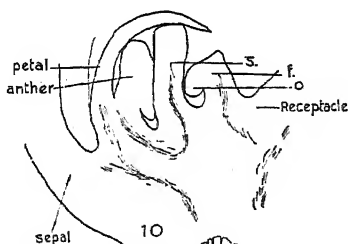
*Discs.*—Each disc consists of a swollen yellow portion united at the base to a petaloid process. In development the petaloid process forms first, the disc appearing later as a minute elevation on the inner surface. A vascular strand enters from the base of the flower and passes into the petaloid process, bending slightly in the direction of the disc, but not entering it. The cells of the petaloid process soon cease to divide and growth becomes limited, but the cells of the swollen portions remain meristematic for a longer time, dividing very rapidly until full size is attained. The cells are typical meristematic cells, very small, with dense protoplasm, all the cells dividing by ordinary cell-division as long as they are active. Although Cheeseman calls these lobes staminodia they never, so far as these observations went, show any sign of becoming staminal structures. There is never any indication of an archesporial cell or cells. It would seem that the petaloid processes appear to represent an inner series of petals, each bearing on its inner surface a swollen portion

bright yellow in colour, which is possibly glandular. The insects which visit the flowers probe about at the base of the petals just where the yellow lobes are situated, but there is nothing in the structure of the lobes to show that they secrete any substance. The cells always remain typical meristem cells until they cease to divide, and by the time the flowers are wide open and insects are paying their visits they become almost empty of cell contents. The other organs of the flower mature at the same time, live for a short time, then they all die.



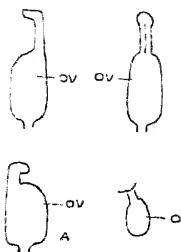
A Vertical Section through a young Flower Bud.  
s = sterile carpel; f = fertile carpel; an = anther.

*Carpels*.—In the formation of the pistil two carpels take part (Fig. 9). Two fibro-vascular strands from the pedicel enter the carpels separately, and the two carpels are unlike, only one being fertile. When mature the fertile sporophyll is much reduced (Fig. 10), being one half the length of the sterile sporophyll, and it bears a single pendulous ovule from its upper end. It takes no part in



the formation of the style, its function being to produce the ovule, and it contributes less than half towards the formation of the ovary. The sterile sporophyll forms the rest of the ovary and the whole of the style. In the development and formation of the pistil the two

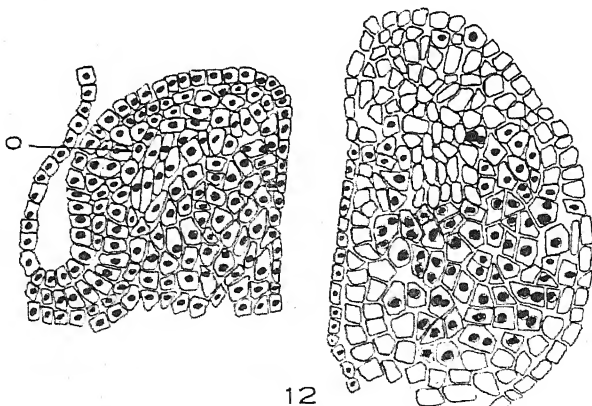
sporophylls meet, so that the margins of the one touch the margins of the other, but the pistil is not radially symmetrical but is bilateral (Fig. 11), first, owing to the unequal length of the two sporophylls, and, second, because the short sporophyll is rounded to contain the



OV. = Ovary; O = Ovule.

ovule. The ovule begins to form very early, when the two sporophylls are almost the same size, and before the margins grow together (Figs. 9 and 12). To form the style the upper half of the sterile sporophyll folds inwards and the margins meet; however, this fusion is not complete, for there is always a groove left running the length of the style. There is also incomplete fusion between the upper part of the fertile sporophyll and the base of the style, so that an opening is left into the ovary at the base of the style, and this opening does not close up until after fertilization. The stigma remains bent (Fig. 11).

*Ovule*.—The ovule begins as a bulge on the surface of the fertile sporophyll very early in its life (Fig. 12). A group of cells just



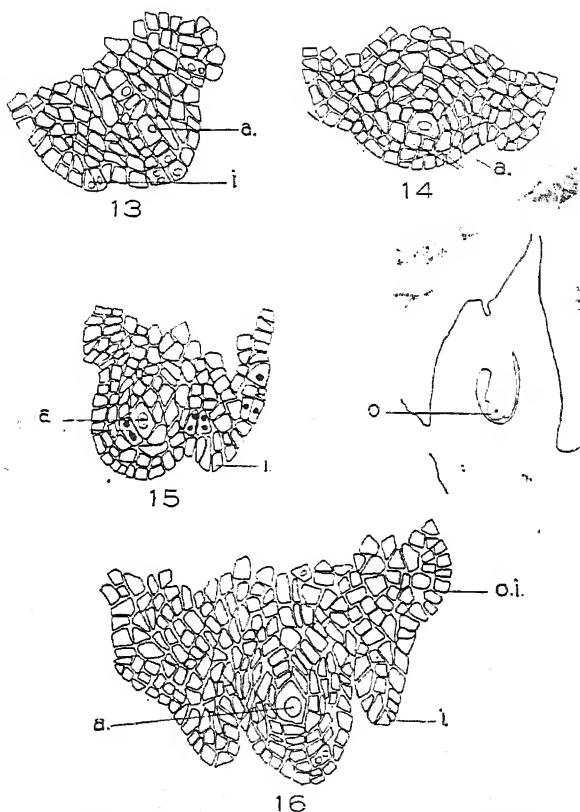
Young Ovule.

Young Anther.

below the epidermis all divide very rapidly in different directions until a pendent group of cells is formed, the nucellus. This rudimentary ovule grows to a diameter of .04 mm. before the integuments begin to form, and this stage is found in unopened buds. This is the period of most rapid growth of the funicle, only a very small

proportion of the mass of cells constituting the nucellus at the apex; the nucellus remains in this small proportion until the archesporium is formed, when the buds are beginning to open. The integuments begin to develop almost at the same time.

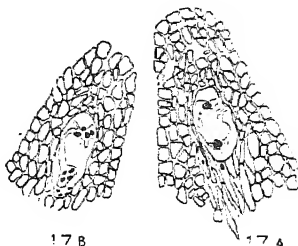
A cell in the middle line of the nucellus, about the third or fourth cell in from the outside, becomes the archesporium (Fig. 14). It divides into two, an inner and an outer cell, and both cells are very large (Fig. 15). The outer cell divides again in a different direc-



a = Archesporium.                      oi = Outer Integument.  
i = Inner Integument.

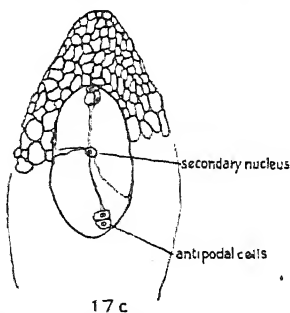
tion, also the cells between it and the outside of the nucellus divide several times, so as to increase the number of cells between the outer layer and the archesporium. The archesporium thus comes to lie at a depth of seven or eight cells in from the outside. Without further division the archesporial cell develops into the embryo sac (Fig. 16). The tiers of cells above it separate slightly in young ovules, leaving a passage down to the embryo sac (Fig. 17, a, b). This would seem to suggest a preparation for the entrance of the pollen-tube, were it not that the passage is closed later on. The anthers complete their development much earlier, and it is usual in July to find pollen-sacs containing cells in tetrad

division. Further development of the ovule takes place most markedly in the nucellus and integuments, for as soon as the arche-



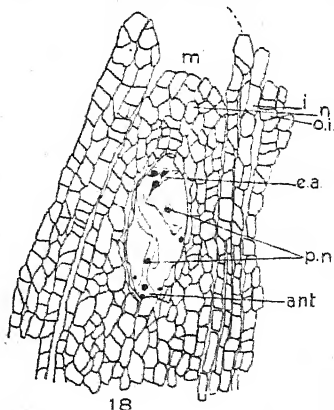
Different stages in development of Embryo Sac.

sporial cell is clearly differentiated the funicle almost ceases to grow. Growth is more rapid on one side, the ovule begins to curve and finally becomes anatropus. The embryo-sac is oval and becomes



Only two Antipodal Cells are shown.

enlarged at the expense of the nucellus. When the length across is from about .002 mm. to .06 mm. the contents are arranged in typical fashion, consisting of two synergidae, an egg-cell, a well-marked secondary nucleus, and a varying number of antipodal cells (Fig.

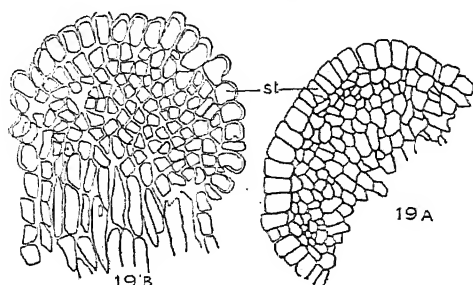


p.n. = Polar Nuclei.  
m. = Microcyte.  
i. = Inner Integument.  
o.i. = Outer Integument.

n. = Nucellus.  
e.a. = Egg Apparatus.  
Ant. = Antipodal Cells.

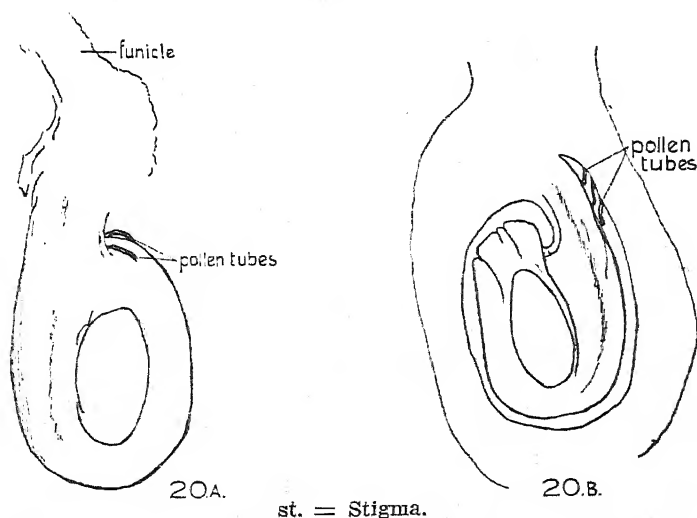
17, c.) ; there may be as many as seven or eight (Fig. 18). Further increase in size of the embryo-sac does not take place until pollen-grains have germinated on the stigma.

*Stigma*.—In unopened buds the stigmatic surface consists of a layer of very large evenly arranged cells, which are in longitudinal section more or less square in outline. When the stigmatic surface is ready to receive pollen these cells separate from one another and



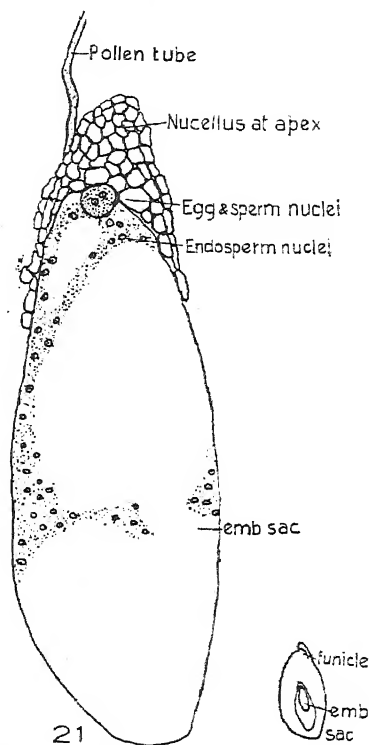
stand a little apart (Fig. 19, a, b). The cells immediately beneath these are small square cells which stain readily, and it is these cells that in unopened buds contain the red colouring matter.

Pollination takes place in November and December, and although a very obvious groove is left along the style by the infolding of the sterile carpel, pollen-grains do not grow down the groove. They always penetrate the tissue of the style, gaining nutriment, and germinate in large numbers. When they come to the opening left by the incomplete fusion of the two carpels, they make their way down



it and enter the ovary near the base of the funicle. Two or three pollen tubes may enter the ovary, one tube is seen to creep over the surface of the ovule near the micropyle, and only one seems to find

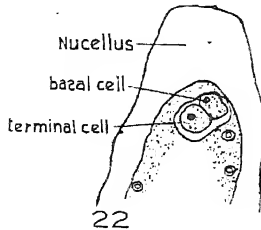
its way in (Fig. 20, a, b.). It finds its way along a little space left between the apex of the nucellus and the integuments, at the side. Actual entry into the embryo-sac was not observed, although in many cases an egg and a sperm nucleus can be seen lying side by side in the same envelope (Fig. 21). Double fertilization has not been observed, but at the time that the egg and sperm nuclei are lying side by side, other cells are formed very rapidly at the micro-



pylar end of the sac. Some very clear cases were observed where these nuclei are all dividing before any appearance of fertilization. These cells newly formed have abundant protoplasm and are at first grouped closely together, but they are not provided with cell walls until later. They soon come to line the embryo-sac, still dividing very rapidly and often are all found in telophase, showing spindles. Then their protoplasm becomes thinner and they secrete cell walls. Embryo-sacs presenting this state of affairs vary in length from .3 cm. to .6 cm. It would seem that these cells are prothallial cells formed before fertilization is complete, distinctly a gymnospermous character.

*Embryo.*—The embryo divides across, forming two cells (Fig 22), a basal cell and a terminal cell. Of these the basal cell does not divide again, and the terminal cell, unlike that in typical Angiosperms, forms the embryo. It divides across twice and further divisions result in a spherical embryo of about sixty-four cells or

more. It is about this time that the prothallial cells secrete cell walls, and then cease to multiply. They form a very loose tissue,



whose cells have large vacuoles, and are gradually used up by the developing embryo. They never occupy the whole embryo-sac, merely forming a lining to it, and the embryo-sac is filled with a watery fluid which may be of value as food material for the developing embryo.

The antipodal cells disappear early, before fertilization, and also the secondary nucleus. At the time of fertilization the embryo-sac increases in size very rapidly; the outer integument keeps pace in development, and in addition becomes thick and fleshy, but the inner integument and the nucellus disappear, except for a small portion at the micropyle, and another small portion below the antipodal end of the sac. The ovary-wall increases greatly, becomes thick and fleshy like the outer integument, and is traversed by a network of fibro-vascular strands. The two integuments and the nucellus are fused quite early in the life of the ovule but not to such an extent as to lose their identity (Fig. 20, b). The outer integument finally forms the greater part of the young seed-coat, and its enormous size results in the compression from side to side of the embryo-sac, which then appears as a narrow slit. As the embryo develops the remainder of the nucellus disappears, also, the outer integument shrivels, so that in a ripe fruit the testa is very thin.

Further development of the embryo gives rise first to the radicle. It develops as a bulge at the micropylar end of the sac. The plumule is very slightly developed, but the cotyledons are enormous and placed with their adaxial sides together, completely filling the embryo-sac.

The ripe fruits smell like pineapples, but the scent is restricted to the ovary wall whose outer layer becomes fleshy and pulpy. The inner layer is fibrous, forming a dense network of fibro-vascular strands which project above the surface, and an imprint of this network is left on the seed-coat. The greater part of the ripe seed consists of the cotyledons. No fluid remains in the embryo-sac.

*Summing up:* The main differences between the karaka and the typical members of the family are these: The absence of resin-canals, the presence in early development of connate stipules, the occurrence of globular hairs on both upper and lower surfaces of the leaf, and of thread-like hairs on the upper surface of the stipules; the appearance of endosperm before fertilization is of interest because it recalls the Gymnosperms. The absence of a suspensor in the embryo also is a notable feature which may possibly be peculiar to the karaka.

## A New Species of Hymenoptera of the Family Xiphydriidae.

By E. S. GOURLAY, First Assistant Entomologist,  
Cawthron Institute, Nelson.

[Read before the Nelson Institute, 1st December, 1926; received by Editor, 9th December, 1926; issued separately, 6th August, 1927.]

(Plate 2.)

IN the Tenthredinoid group of the Hymenoptera, New Zealand has endemic representatives of the families Xiphydriidae and Oryssidae only. Of the Xiphydriidae there is one species, *Xiphydria decepta* Smith, and of the Oryssidae there is one species, *Ophrynopus schauinslandi* Ashmead. In 1901, the latter insect was described from the Chatham Islands, and the writer (1925) added to the record instances of its occurrence on the mainland of New Zealand. *X. decepta* is rare, and but for one notable instance recorded in 1925, the same remark applies to *O. schauinslandi*.

The species described hereunder brings the total number of Tenthredinoid Hymenoptera to three, and it would appear that all are subalpine.

### Family XIPHYDRIIDAE.

#### Genus *Xiphydria*.

#### *Xiphydria duniana* n. sp.

♀. 8 mm. Head shining, black, except mandibles which are castaneous, the teeth black, and palpi, brown, greatly suffused with black; clypeus, cheeks, scape, palpi and mandibles, covered sparsely with moderately long amber-coloured hairs, longest and thickest on the cheeks. Clypeus overlapping mandibles laterally, having a small sharp triangular tooth medially. Frons, between the antennae, conical, flattened above, and having a depression medially which ends at the anterior ocellus. Antennae 20-jointed, lying in a broad vertical furrow, widest at the insertion of the antennae, and narrowing just above them to continue as a shallow fossulet to the lateral ocelli. Thorax black dorsally, shining; brownish laterally and ventrally, more or less suffused with black, the base of the episternum black. Pronotum and episternum covered with long pale brown hairs, the lateral angles of the former yellow. Parapsidal grooves and a median longitudinal groove on the scutum deeply pitted, the former wide, the latter narrow. Scutellum flat, with steeply declivous sides. First abdominal spiracles large, prominent. Wings hyaline, highly iridescent, the nervures and stigma dark brown. Legs dark brown, suffused with black, the latter colour being present in greater proportion in the fore coxae, trochanters and femora. All the coxae slightly hairy; the hind tibiae and tarsi densely clothed with moderately long pale brown hair. Abdomen black dorsally, brown suffused with black ventrally, shining. Laterally, a cream spot on segments four, five and six, and a large oblique cream mark on segment nine. On each of sternites four to eight a row of pale brown hairs; segments nine and ten have a patch laterally. Sheaths of ovipositor also hairy, dark brown suffused with black.

Taken resting on *Uncinia* sp. growing in the open and close to a large clearing among mixed *Nothofagus* forest.

One specimen, from "Third House," Dun Mountain, 2,000 feet, in February, 1926. Holotype (♀) in Coll. Cawthron Institute.

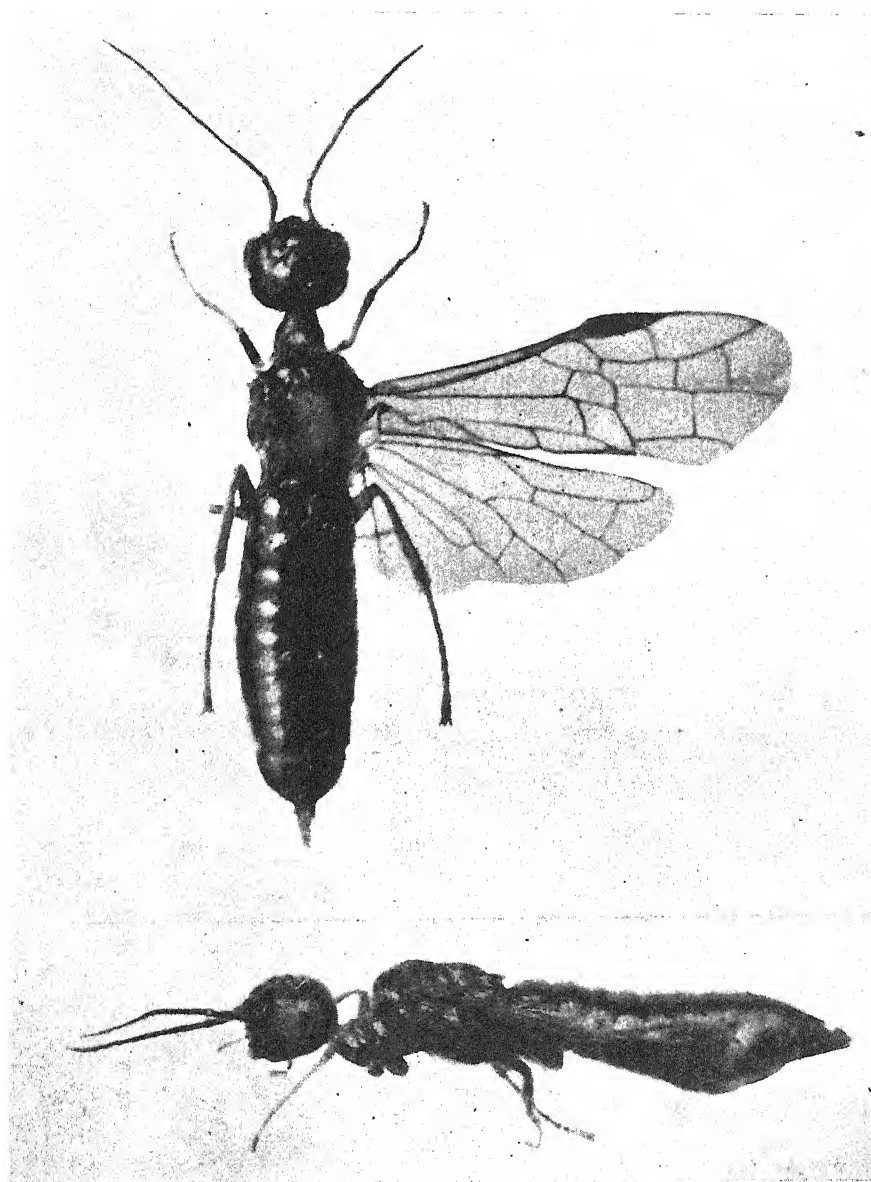


FIG. 1. *Xiphydria duniana* n. sp. holotype.

FIG. 2. *Xiphydria duniana* n. sp. holotype, lateral view.



## Notes on Variation in Neural Structure of New Zealand Cicadas.

(Genus *Melampsalta*.)

By G. V. HUDSON, F.E.S., F.N.Z. Inst.

[Read before the Wellington Philosophical Society, 25th August, 1926;  
received by Editor, 26th August, 1926; issued separately,  
4th August, 1927.]

THROUGH the kindness of Mr. S. Lindsay, of Christchurch, I have had the pleasure of adding to my collection a fine specimen of that very interesting little cicada, *Pauropsalta lindsayi* Myers. In describing this new form\* Mr. Myers explains that the genus *Pauropsalta*, of which this is the first New Zealand exponent, is distinguished by the possession of only five apical cells in the wings (hind-wings). On the receipt of Mr. Lindsay's specimen I examined its neururation, and found that whilst the right wing had five apical cells characteristic of the genus *Pauropsalta* the left had six apical cells characteristic of *Melampsalta*. A cursory examination of a few specimens of various species of *Melampsalta* convinced me that the character relied on for generic separation was variable, and I therefore decided to examine the neururation of the hind-wings of the whole of the Cicadas in my collection, embracing 197 specimens belonging to 15 species. I must here explain that Mr. Myers has very kindly advised me that he has examined the types of our New Zealand Cicadas in the British Museum, and he finds certain amendments in nomenclature are necessary. Doubtless he will shortly communicate these amendments to the New Zealand Institute, but in the meantime, I desire to use the amended names supplied to me by Mr. Myers. In order therefore to make the matter quite clear and, at the same time avoid anticipating Mr. Myers, I give under each species a reference to Plates 45 and 46 in volume 53, *Trans. N.Z. Inst.*, so as to indicate precisely what species is meant. I may add that these plates were prepared by myself, from my own specimens, to illustrate the paper by Mr. Myers which they accompany.

The results of the detailed examination of my collection of Cicadas are as follows:—

*Melampsalta cingulata* Fabr. (Plate 45, figs. 5 and 6.) Five specimens examined. Six apical cells in hind-wings. No variation.

*Melampsalta strepitans* Kirkaldy. (Plate 45, fig. 7.) Thirteen specimens examined. One male with seven apical cells in right wing and six in left wing.

*Melampsalta cauta* Myers. (Plate 45, fig. 8.) Five specimens examined. Six apical cells. No variation.

*Melampsalta scutellaris* Walk. (Plate 46, figs. 3 and 4.) Twelve specimens examined. One female with five apical cells in right wing, six in left wing. One female with five in left wing and six in right

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\* *Trans. N.Z. Inst.*, 56, 430.

wing. One male with small supplementary cell near apex in left wing.

*Melampsalta leptomera* Myers. (Plate 46, fig. 1.) Two specimens examined. Six apical cells. No variation.

*Melampsalta cruentata* Fabr. (Plate 45, fig. 11.) Seventeen specimens examined. One male with small supernumerary cell in both wings differently placed on each. One female with five apical cells in left wing. One male with five in right wing.

*Melampsalta muta* Fabr. (var. *sub alpina*.) (Plate 46, figs. 12 and 13.) Twenty-six specimens examined. One male with small supernumerary cell in right wing near apex. One female with two small supernumerary cells in each wing differently placed. One male with first apical cell of left wing divided transversely into two.

*Melampsalta muta* Fabr. (Plate 46, figs. 9, 10, 11.) Forty-two specimens examined. One female with first apical cell in both wings divided transversely. One male with small extra cell in left wing. One male with five apical cells in left wing. One male with two minute extra cells in left wing. Two females with minute extra cell in right wing. One female with seven apical cells in right wing. One female with small extra cell in left wing. One male with seven apical cells in left wing. One male with seven apical cells in right wing.

*Melampsalta sericea* Walk. (Plate 46, figs. 7, 8.) Ten specimens examined. One male with five apical cells in right wing. One male with five apical cells in left wing.

*Melampsalta ochrina* Walk. (Plate 46, figs. 5, 6.) Thirteen specimens examined. Six apical cells. No variation.

*Melampsalta nigra* Myers. (Plate 45, figs. 1, 2.) Ten specimens examined. One female with small extra cell near apex of right wing. One female with minute extra cell in left wing. One male with seven apical cells in left wing.

*Melampsalta cassiope* Huds. (Plate 45, figs. 3, 4.) Twenty-two specimens examined. One male with five apical cells in both wings. One male with four apical cells in both wings. One female with small extra cell in right wing. One female with five apical cells in right wing.

*Melampsalta iolanthe* Huds. (Plate 45, fig. 9.) Fifteen specimens examined. One female with five apical cells in right wing. One female with five apical cells in left wing.

*Melampsalta campbelli* Myers. Two specimens examined. Six apical cells. No variation.

*Melampsalta hamiltoni* Myers. Two specimens examined. One male with five apical cells in right wing.

*Pauropsalta?? lindsayi* Myers. One specimen (male). Right wing with five apical cells; left wing with six apical cells.

It will thus be seen that out of the 197 specimens examined, no less than 33 individuals, or over 16 per cent., exhibited variation in the neuration of the hind-wings. It is hardly necessary to point out that investigations of this character have an important bearing on the ultra-refined methods of modern systematists. New genera and new species are constantly being described, based on small structural differences, often arrived at by the examination of only one or two specimens.

## Notes on New Zealand Geometridae.

By LOUIS B. PROUT.

Communicated by ALFRED PHILPOTT.

[Read before the Nelson Philosophical Society, 9th December, 1926;  
received by Editor, 11th December, 1926; issued separately,  
6th August, 1927.]

As Mr. Meyrick remarked nearly ten years ago (*Trans. N.Z. Inst.*, 49, 248), our knowledge of this family—or group of families, if his view and that of Dr. A. J. Turner be accepted—is already well advanced, and on that account it seems all the more worth while to bring together such corrections in nomenclature, etc., as have been discovered since the appearance of his valuable “Revision” (*tom. cit.* pp. 251-270). I take that memoir as a basis, so far as regards sequence and classification, except where there are actual discrepancies between the generic diagnosis and included species. I have had some interesting correspondence with Mr. A. Philpott on the questions at issue, and in the few cases where we have not been able to reach practical certitude I think it advisable to postpone definite alterations.

### Tatosoma Butl.

Mr. Meyrick remarks on the affinity between this genus and *Rhopalodes* Guen., and says that the former differs “only” in the unusual elongation of the male abdomen. He overlooks the interesting fact that *Tatosoma* has lost one of the proximal spurs of the hindtibia, which is not the case with *Rhopalodes*.

2. *T. tipulata* Walk. The synonym *mistata* Feld. belongs to this species, not to *agrionata*.

4 bis. *T. apicipallida* Prout. This is a quite different species from *alta* Philp.

7. *T. timora* Meyr. The oldest reference is *N.Z. Jour. Sci.* 2 (5), 234 (September, 1884), where the name stands as nom. nov. for “*agrionata* nec. Walk.”

### Microdes Guen.

11. *M. quadristrigata* Walk. = *interclusa* Walk. = *toriata* Feld. = *rectilineata* Huds. is at least a race, if not a separate species. *M. villosata* Guen. is Australian.

### Phrissogonus Butl.

13. *P. Testulata* Guen., *Lep.*, 10, 352, is the oldest name for *denotata* Walk.

### Chloroclystis Hübn.

14. *C. inductata* Walk. Add as further synonym *semilineata* Feld., *Reis Nov.* pl. 131, 36 (♀).

17. *C. plinthina* Meyr. The reference should be 20 (not 21), 49.  
 32. *C. modesta* Philp., *Trans. N.Z. Inst.*, 47, 193. This name is preoccupied by *Chloroclystis modesta* (Warr.) Hmps., *Faun. Ind. Moths*, 3, 396. I propose the name *acompsa* nom. nov.  
 36. *C. lichenodes* Purdie. The reference should be 19 (not 20), 70.  
 37. *C. fumipalpata* Feld., *Reis Nov.* pl. 131, 33, is—as has recently been pointed out by Mr. Philpott (*Trans. N.Z. Inst.*, 56 388)—the oldest name for *maculata* Huds.  
 39. *C. minima* Huds. This name is preoccupied by *Chloroclystis minima* Warr., *Nov. Zool.*, 4, 227, but as I am inclined to agree with Hudson and Philpott (*Trans. N.Z. Inst.*, 49, 203) in making it a dwarf form of *nereis* Meyr. I leave it in abeyance.

“*Asthena* Hübn.” (Meyr.)

Unless *subpurpureata* Walk. is a remarkable colour-form of *pulchararia*, there are three New Zealand species in this genus, all of “the Australian type” thereof, i.e., the genus *Poecilasthena* of Warren and Turner; but the first one, like *xylocyma* Meyr. (*Proc. Linn. Soc. N.S.W.* (2), 5, 815), does not literally conform to the diagnosis “hindwings normal.” I separate the two which have been confused as *schistaria* by numbering them 58 and 58 bis.

58. *A. schistaria* Walk. Differs from the following in having the hindwing more rounded, not bent at vein 4; on the underside in the male with a specialised tuft of hair at tornus, as in *xylocyma* Meyr.; also often in having the post-median line of the forewing stronger (in any case not accompanied by a band) and the proximal post-median of the hindwing stronger than the distal, whereas in *subpurpureata* the reverse is the case, or the two are equal in expression, often united by a band-like shade. From Mr. Meyrick's remarks in erecting *xylocyma*, it would be pretty safe to add that name as a synonym to *schistaria*, but I have not yet made acquaintance with the Australian representative.

58 bis. *A. subpurpureata* Walk. = *tuhuata* Feld. A further synonymy is *polycymaria* Hmps. (*Jour. Bomb. Nat. Hist. Soc.*, 14, 648), the type of Hampson's genus *Astheniodes*, based on a single example merely labelled “India,” evidently in error. I have carefully compared Hampson's type with New Zealand material.

“*Venusia* Curt.” (Meyr.)

61. *V. dissimilis* Philp. Must be transferred to *Xanthorhoe* (sens. lat.), as already noted by the author, *Trans. N.Z. Inst.*, 56, 388.

**Orthoclydon Warr.**

*Orthoclydon* Warr., *Nov. Zool.*, 1, 393 (1894)); type, *P. praelectata* Walk. (No. 125 in Meyrick.)

This genus has been overlooked, although Turner and Philpott have recently (*Trans. N.Z. Inst.*, 56, 388) noted that *praelectata* Walk. required a separate genus, failing in two of the four signifi-

cant characters which Meyrick uses for *Xanthorhoe*—frontal cone and “moderate rough-scaled” palpus. The face is smooth, slightly rounded (especially in the type species), but not so prominent as in *cambrica* Curt., the type of *Venusia*. Palpus rather short, very shortly rough-scaled beneath (much as in “*Venusia*” *charidema* Meyr.). Antennal pectinations of ♂ very long, with about 10 distal segments non-pectinate (much as in *V. verriculata* Feld.). Thorax and abdomen not crested. Forewing with apex acute, or even sub-falcate, scaling smooth, pattern typically consisting of lines, as in the *Asthenia* group; areole double, vein 6 well stalked, DC more or less strongly inbent in middle, 5 arising from slightly before its middle, 3 considerably proximal to end of cell. Hindwings continuing the scheme of forewing (i.e., presumably exposed at rest), DC oblique, vein 5 arising well before its middle, 3 as in forewing.

Thanks to the kindness of Mr. Philpott, I have been able to study also *pseudostinaria* Huds. (*Ent. Mo. Mag.*, 44, 61), which he rightly transfers here. I do not know *chlorias* Meyr., but fully accept Mr. Philpott’s placing; its synonym *princeps* Huds. was erected in *Venusia*, which was evidently nearly right as to the frons, but overlooked the double areole.

### *Asaphodes* Meyr.

69. *A. parora* Meyr. The oldest reference is *N.Z. Jour. Sci.*, 2 (5), 234 (1884), nom. nov. for “*humeralia* Meyr. nec. Walk.”

### *Xanthorhoe* Hübn. (sens. lat.).

81. *X. lucidata* Walk. Add synonym *robustaria* Walk., *Cat.*, 25, 1320, which represents the male, the types of *lucidata* and *plurimata* being females. Meyrick gives no localities, but the species is known from Porirua, New Plymouth, etc.

84. *X. subductata* Walk. Walker’s type is simply a ♀ *rosearia* Doubl. Is Meyrick’s one Auckland example the same?

91. *X. falcata* Butl. Is an *Asaphodes* and must stand for the present as 70 bis. Personally, I feel satisfied that it is nothing but a large dark rufescens Butl., but as I have not seen any other example like it and Mr. Philpott cannot, from Butler’s description, reconcile the two, I forbear to merge them.

96. *X. subobscurata* Walk. Add the synonym *ascotata* Feld., *Reis. Nov.*, pl. 131, 9.

101. *X. benedicta* Meyr. This species is the true *beata* Butl. (*Proc. Zool. Soc. Lond.*, 1877, 397, pl. 43, 6), as is shown by his type. In his careful separation of the two allies, 101 and 102, Mr. Meyrick (*Trans. N.Z. Inst.*, 46, 102), misjudged which was Butler’s species and gave a name to the wrong one. This was perhaps excusable, if he was unable to visit London at the time, for, as Mr. Philpott has pointed out to me, the original description and figure are very misleading in some ways. But inasmuch as the other species was not even represented in the British Museum collection in 1877, there can be no question of a confusion in labelling the type.

102. “*X. beata* Butl.,” Meyr., *Trans. N.Z. Inst.*, 46, 102; 49, 260. As this species is left without a name I propose for it that of *Larentia*

*philpotti*, nom. nov., in honour of the entomologist who first recognised that two species were mixed as *beata*. In addition to the differences originally pointed out by Meyrick, which are quite adequate for purposes of recognition, there is a pretty constant distinction in DC of the hindwings, though both are "*Larentia*" in having a definite angulation, with vein 5 arising posteriorly to the cell-fold. By some unexplained discrepancy, Mr. Meyrick (*Trans. N.Z. Inst.*, 49, 249) finds the discocellulars more extreme in *philpotti* (his "*beata*") than in *beata vera* (= *benedicta*), but both Mr. Philpott and myself have examined a very large number, with the results here indicated. In *beat* = *benedicta* (the species with the cell-spot developed on the forewing) vein 5 of the hindwing is always nearer to 4 than to the cell-fold. In *philpotti* (cell-spot absent or vestigial) 5 is nearer to cell-fold than to 4, sometimes only slightly so, occasionally only halfway. The deviation, therefore, is sometimes only small, and it is conceivable that specimens of one or the other species might be found in which the distinction would break down, but it is certainly not without significance.

104-106. *X. chorica* Meyr., *cymozeugta* Meyr. and *obarata* Feld. Mr. Philpott and Mr. Meyrick correctly found (*Trans. N.Z. Inst.*, 51, 350) that there were only two species here, but as there has been a misidentification of Felder's *obarata*, of which the type is extant in the Tring Museum, the synonymy will need rectification. No. 104 will stand as *obarata* Feld., with *chorica* Meyr. sunk to it; No. 105 = 106 as *cymozeugta* Meyr. (= *obarata* Meyr. nec Feld.).

### Notoreas Meyr.

139. *N. perornata* Walk. This common species must, on Meyrick's system of classification, be transferred to *Lythria*, as the areole is always simple.

### Dasyuris Guen.

152. *D. callicrena* Meyr. Similarly, this species must be transferred to *Dasystemica* Turn. (*Trans. R. Soc. S. Austral.*, 46, 256) on account of the simple areole.

156. *D. fulva* Huds. Has already been transferred to *Notoreas* (Huds., *Trans. N.Z. Inst.*, 40, 107, in erecting *Dichromodes simulans*), and this is right as regards the pectinate male antenna. The areole is variable, though with some bias in the direction of *Notoreas*, in which the species may be provisionally left. Although it is now known that there are a good many species in which the areole can be either simple or double, it is seldom that there is not such a strong preponderance of one or the other condition as to justify the temporary retention of the character as generic. The condition of the male antenna (pectinate or non-pectinate) is quite stable for species, but sometimes gives such arbitrary divisions that it would be impossible to divine, in the absence of the male, whether a species belonged, e.g., to *Dasyuris* or *Notoreas*. The form of the discocellulars of the hindwing, though rejected as generic by Mr. Meyrick, was contemporaneously pronounced by Dr. Forbes (*Journ. N.Y. Ent.*

Soc., 25, 45) to be probably the best differential character yet available in the very difficult *Cidaria* group, as generally correlated with a somewhat fundamental difference in the male genitalia.

**Adeixis Warr.**

164. *A. inostentata* Walk. It has already been pointed out (*Trans. N.Z. Inst.*, 53, 339) that the New Zealand species is distinct from the Australian, and must be called *griseata* Huds.

**Dichromodes Guen.**

166 (165 [bis] ex err. typogr.). *D. petrina* Meyr. Sinks to *sphaeriata* Feld. Mr. Meyrick only cites Felder's name with a query, which is not unnatural if he judged only by the bad figure, but overlooks that the type is accessible in the Tring Museum.

**"Epirranthis Hübn." (Meyr.)**

171 bis. *E. ustaria* Walk. is a separate species from *alectoraria*. Vide Philpott, *Trans. N.Z. Inst.*, 49, 211; Prout in Seitz, *Macrolep.*, 12, 34. Since the latter was written the genitalia have been examined.

**"Selidosema Hübn." (Meyr.)**

176. *S. cremnopa* Meyr. This sinks to *pungata* Feld. (vera), *Reis. Nov.*, pl. 131, 23, but both are simply male forms of the true *melinata* Feld., pl. 129, 9 (nec Meyr.). As the latter has at least "page priority," this rather rare species should be registered as *melinata* Feld. (♀) = *pungata* Feld. (♂) = *cremnopa* Meyr. (♂).

176 bis. *S. flava* Warr., *Nov. Zool.*, 3, 406 (1896). Overlooked by New Zealand workers. It may be an aberration of one of the known species, e.g., of *fasciata* Philp. with the dark markings extraordinarily reduced.

177. *S. fasciata* Philp. This name must be resuscitated (see 176 supra).

184. *S. indistincta* Butl. = *melinata* Meyr. nec Feld. This name must be resuscitated (see 176 supra).

**"Azelina Guen." (Meyr.)**

200. *A. ophiopa* Meyr. Sinks to *variabilis* Warr., *Nov. Zool.*, 2, 153 (1895) (as *Polygonia*). The description was poor, and in the absence of a type locality (though the comparison with *fortinata* might lead to a guess) the name has been lost sight of.

202. *A. gallaria* Walk. Further synonyms are *Ischalis thermochromata* Walk., *Cat.*, 26, 1750 and *cineria* Feld., *Reis. Nov.*, 132, 22 (as *palthidata* var?).

**Declana Walk.**

205. *D. griseata* Huds. Belongs in Sect. B.

208. *D. feredayi* Butl. Is the oldest name for *sinuosa* Philp. and must be deleted from the synonymy of No. 207.

## Notes and Descriptions of New Zealand Lepidoptera.

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera,  
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by Editor, 7th October, 1926; issued separately  
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### NOCTUIDAE.

**Ichneutica marmorata** (Huds.), *Ent. Mo. Mag.*, vol. 60, p. 7; *I. dives* Philp., *Trans. N.Z. Inst.*, vol. 55, p. 207.

The above synonymical correction is necessary. This handsome species was found to be not uncommon at Arthur's Pass in February.

### **Melanchra badia** n. sp.

♂. 38 mm. Head greyish-brown. Palpi greyish-brown, terminal segment and apex of second segment mixed with ochreous. Antennae minutely ciliated; ferruginous, basal third ochreous-grey. Thorax with slight anterior crest, greyish-brown. Abdomen grey mixed with fuscous, anterior segments prominently crested, each crest with apical blackish bar. Legs ochreous, middle and anterior pair mixed with brown, anterior tarsi more or less infuscated. Forewings moderate, costa almost straight, apex rectangular, termen rounded, rather oblique, crenulate; chestnut-brown; costa narrowly, and termen more widely, greenish-olive; an indistinct, paired angled fuscous fascia near base; a pair of blackish dots on costa at  $\frac{1}{3}$  and three others before and above reniform; costa between these dots greyish-ochreous; orbicular ovate, dark fuscous ringed with ochreous-white; reniform narrow, inner basal angle somewhat produced, blackish, margined with ochreous-white; claviform obscure, fuscous, margined anteriorly with ochreous-white; second line indicated by dull serrate paired fasciae, excurved to middle, thence incurved to dorsum; subterminal line prominent, margining olive terminal band, ochreous-white; an indistinct waved blackish terminal line; fringes brown with pale basal and dark median crenulate lines. Hindwings dark fuscous; fringes ochreous-whitish with broad fuscous basal line.

There is a slight resemblance to some forms of *M. tartarea* Butl., but the minute ciliations of the antennae at once distinguish it.

Leslie Valley, in November. A single male (holotype) in coil. Cawthron Institute.

### **M. captiosa** n. sp.

♀. 41 mm. Head and palpi ochreous-white. Antennae brown, basally ochreous-white. Thorax with bifid anterior crest, ochreous-white mixed with pale olive. Abdomen ochreous-white, dorsally fuscous. Legs whitish-ochreous, tarsi annulated with reddish-brown, terminal segments of anterior tarsi wholly brown. Forewings elongate, costa almost straight, apex rectangular, termen rounded, oblique, crenulate; ochreous-white; numerous obscure dentate pale brownish-olive transverse fasciae and a few scattered black scales; reniform indicated by blackish dots; subterminal line indicated near

tornus and above middle by blackish margining; fringes brownish-olive and fine waved median whitish line. Hindwing fuscous, pinkish-fuscous round termen; fringes pinkish-brown, round dorsum wholly whitish.

Not close to any other described *Melanchra*.

Mount Arthur Tableland at about 4,000 feet, in November. The single specimen (holotype) is in the coll. Cawthron Institute.

***Melanchra lata* n. sp.**

♀. 44 mm. Head, palpi and thorax pinkish-brown mixed with grey. Antennae brown, greyish basally. Abdomen pinkish-grey. Legs greyish-brown, tarsi annulated with whitish. Forewings broad, dilated posteriorly, costa almost straight, apex obtuse, termen straight on upper half, rounded beneath; pinkish-grey; a short median longitudinal black fascia from base, apically dilated; first line indistinct, greyish, from  $\frac{1}{3}$  costa to before  $\frac{1}{2}$  dorsum, dark-margined posteriorly; orbicular large, greyish, margined with black; claviform touching first line, obscure, dark-margined above; reniform large, normal in shape, black-margined; an obscure dark shade inwardly oblique from bottom of reniform to dorsum; second line curved, waved, greyish, anteriorly dark-margined; subterminal well-defined, greyish, indented beneath costa, anteriorly dark-margined, margining dilated above tornus; a terminal series of black dots; fringes pinkish-grey with a faint median pale line. Hindwings greyish-fuscous; a thin black terminal line; fringes pale pinkish-grey.

Approaching *M. olivea* Watt, but much broader-winged and with a differently formed basal fascia.

Arthur's Pass, in February. Taken at light. The only specimen obtained (holotype) is in the coll. Cawthron Institute.

***Catada lignicolaria* Walk., Cat. Brit. Mus., 35, 1579.**

Three specimens of this Tasmanian insect were sent to me by Mr. D. D. Milligan, of Leigh, North Auckland, who took the insect in that locality in January. It is the species formerly recorded from Thames as *C. impropria* Walk. by Mr. Meyrick (*Trans. N.Z. Inst.*, 49, 246), but Dr. Jefferis Turner assures me that the New Zealand insect is *C. lignicolaria*, and having had an opportunity of examining examples of *C. impropria*, I have no hesitation in accepting his identification.



FIG. 1. *Catada lignicolaria* Walk. Harpe.

FIG. 2. *Catada impropria* Walk. Harpe.

**HYDRIOMENIDAE.**

***Chloroclystis punicea* Philp., Trans. N.Z. Inst., 54, 148.**

Several of this rather rare species were taken at Nelson by Mr. W. Heighway during the past season. Among these were three females, and I have selected one for the allotype and placed it in the coll. Cawthron Institute.

## PSYCHIDAE.

*Clania tenuis* Rosen., *Ann. Nat. Hist.*, 16 (ser. 5), 422.

In August, 1925, Mr. Gilbert Archey, Director of the Auckland Museum, sent me a lepidopterous larval case, which had been found on some imported Australian timber. It contained a living larva and, thinking it to be a species of *Entometa*, I supplied it with *Eucalyptus* leaves. It did not, however, eat anything and soon fastened the case to the surface of a leaf and remained there. Some time in the late summer the moth emerged, but owing to my absence on field work, I did not know of this till the middle of April. A full description of *C. tenuis* is to be found in Meyrick and Lower's "Revision of the Australian Psychidae" (*Trans. Roy. Soc. S. Aus.*, vol. 31, p. 197). The expanse of wing is about 22 mm. The head, thorax and abdomen are black, the face and tegulae white, and there are two white stripes on the thorax. The wings are light fuscous minutely irrorated with black. The larval case is an interesting object. It is rather more than an inch long and covered with straight twigs of about the thickness of a knitting needle, regularly laid and securely fastened to the underlying silk. Between most of these larger twigs are very much thinner ones, the whole resembling a fagot in miniature. The specimens have been returned to the Auckland Museum.

## CRAMBIDAE.

*Crambus ornatus* n. sp.

♂. 20 mm. Head and palpi ochreous. Antennae brown. Thorax brown mixed with white. Abdomen whitish-ochreous. Legs white, anterior pair fuscous. Forewings, costa moderately arched, apex blunt-pointed, termen rounded, oblique; brassy brown to chocolate brown; markings white; a basal patch on costa half enclosing a brown area; a broad irregular band at  $\frac{1}{4}$ , not reaching dorsum, outwardly strongly dentate; on fold before this a large spot of mingled blackish and white scales; an elongate black mark about middle of wing at  $\frac{1}{3}$ ; a crescentic white area sprinkled with brown on costal half from about  $\frac{1}{3}$  to  $\frac{4}{5}$ , enclosing an elongate spot of blackish-brown on costal margin; beneath this costal spot a prominent ring of brown enclosing a white area with a central brown dot; second line pure white, dentate, preceded on costa by a small blackish-brown dot and followed by a much larger one; a white area beneath the latter reaching apex; fringes fuscous, irregularly barred with white. Hindwings and fringes pale ochreous-grey.

Somewhat like *C. vulgaris* Butl. but the circular distal spot and the broad first line at once distinguish it.

Golden Downs, in January. The single male (holotype) is in the coll. Cawthron Institute.

## PYRAUSTIDAE.

*Scoparia oculata* n. sp.

♂ ♀. 19-22 mm. Head and palpi brown mixed with white. Antennae brown, in male minutely ciliated. Thorax purplish-brown. Abdomen ochreous-grey. Legs ochreous-white, spurs brown. Forewings moderate, costa almost straight, apex rectangular, termen hardly rounded, oblique; dull purplish-brown; markings usually

absent, except reniform which is blackish, and obscurely X-shaped, the lower half being filled with white; in some specimens the veins are faintly outlined in black and there is an obscure subterminal line; fringes greyish-brown with a darker basal line. Hindwings fuscous-grey; fringes greyish-white with brownish basal line.

A very obscure form, but not closely related to any other species.

Nelson, in April and November; Tisbury, Southland, in November; and Freestone Hill, Manapouri, in February.

Holotype (♀) in coll. Cawthron Institute, allotype (♂) in coll. A. Philpott and paratypes in colls. E. Meyrick, A. Philpott and Cawthron Institute.

**Scoparia autumnna** n. sp.

♂ ♀. 25–27 mm. Head white mixed with fuscous. Palpi dark brown, white within. Antennae brown, in male minutely ciliated. Thorax grey, tegulae with broad longitudinal stripe of blackish-brown. Abdomen greyish-ochreous, apically somewhat fuscous. Legs white irrorated with fuscous, anterior tarsi purplish-fuscous annulated with white. Forewings moderate, costa moderately arched, apex rectangular, termen hardly rounded, slightly oblique; grey mixed with white; markings dark chocolate brown; a median streak from base of about  $\frac{1}{3}$ , more or less interrupted with white apically; a streak above this, rising at  $\frac{1}{4}$  and ending at  $\frac{3}{4}$ , its upper margin irregularly indented; some ochreous suffusion round apex of this streak; veins finely lined with chocolate brown; fringes grey with median and subapical lines. Hindwings ochreous-grey, round apex and termen fuscous-tinged: fringes ochreous-grey with fuscous basal line.

Near *S. falsa* Philp. but that species is without the basal streak and the dark lining of the veins.

Nelson, in April and May. Holotype (♂), allotype (♀) and one paratype in coll. Cawthron Institute.

TORTRICIDAE.

**Capua arcuata** Philp., *Trans. N.Z. Inst.*, vol. 47, p. 198.

Mr. A. Tonnoir has submitted to me the previously unknown male of this species. It was taken at Deans' Bush, Christchurch, in March. I have made the specimen the allotype and returned it to the coll. Canterbury Museum.

**Epichorista speciosa** n. sp.

♂. 14 mm. Head, palpi and thorax ferruginous. Antennae ringed alternately with ochreous-grey and black, ciliations in male  $1\frac{1}{2}$ . Abdomen dark greyish-fuscous. Legs greyish-ochreous, anterior pair fuscous, all tarsi annulated with ochreous. Forewings, costa straight, apex almost rectangular, termen slightly rounded, little oblique; white; markings ferruginous mixed with ochreous and black; a small basal patch, including costal fold, margin outwardly oblique; a prominent fairly broad straight fascia from apex of costal fold to before  $\frac{1}{2}$  of dorsum, outer margin extended in disc by ochreous patch; an outwardly oblique broad fascia from middle of costa, greatly constricted (almost interrupted) at middle, thence much

dilated and recurved to apex; several spots on costa between  $\frac{1}{2}$  and apex, and some irregular markings between fasciae on dorsum, where the ground-colour is leaden grey; fringes ferruginous, tipped with yellowish-ochreous. Hindwings dark fuscous; fringes fuscous with darker basal line, round tips ochreous.

Near *E. zatrophana* Meyr. but a larger and more handsome species.

Arthur's Pass, in February. The single male (holotype) was taken by Mr. S. Lindsay in whose collection it remains.

***Tortrix maculosa* n. sp.**

♂ ♀. 14–20 mm. Head, palpi and thorax grey. Antennae grey annulated with fuscous, ciliations in male 1. Abdomen greyish-white. Legs greyish-white, anterior pair fuscous. Forewings, costa well arched, apex round-pointed, termen oblique, white, irrorated with lighter and darker bronzy-fuscous; markings dark bronzy-fuscous; three or four interrupted curved fasciae between base and  $\frac{1}{2}$ ; a rather broad outwardly oblique fascia from before  $\frac{1}{2}$  to middle of wing, dilated in disc; three or four interrupted fasciae between this and apex; fringes greyish-white. Hindwings fuscous-grey; fringes fuscous-grey with pale basal line.

Not closely resembling any other New Zealand *Tortrix*. It is easily recognised by its spotted appearance.

Aorere River and Quartz Ranges, in February. Fairly common on the "pakihi" lands. Holotype (male), allotype (female), and a series of paratypes in coll. Cawthron Institute.

GELECHIIDAE.

***Thiotricha lindsayi* n. sp.**

♂. 15 mm. Head, palpi and thorax purplish-brown. Antennae light purplish-brown, longest ciliations in male 4. Abdomen (missing). Legs fuscous, tarsi obscurely ringed with whitish. Forewings parallel-sided, costa hardly arched, subsinuate, apex broadly rounded, termen oblique; purplish-brown with a sprinkling of whitish scales, especially on posterior half; fringes fuscous. Hindwings and fringes fuscous.

Not likely to be confused with the other two species of the genus. Glentui, in February. A single male (holotype) in coll. S. Lindsay.

ELACHISTIDAE.

***Elachista sagittifera* n. sp.**

♂. 11.5 mm. Head ochreous-white with median brown stripe. Palpi white. Antennae greyish-fuscous. Thorax white, tegulae and median stripe fuscous. Abdomen white mixed with fuscous. Legs ochreous-white mixed with fuscous. Forewings, costa almost straight, apex acute, termen extremely oblique; white; base of costa to  $\frac{1}{4}$  narrowly fuscous; a whitish-ochreous stripe along costa, broadest on basal  $\frac{1}{2}$ ; an ochreous stripe along fold to  $\frac{2}{5}$ ; an ochreous-fuscous stripe above fold, commencing about  $\frac{1}{3}$  and running to apex, where it becomes slightly dilated and blackish; a fuscous stripe along dorsum to tornus, thence continuing, but much paler, half way to apex; fringes pale ochreous-fuscous with black basal line round apex. Hindwings dark fuscous; fringes pale ochreous-fuscous.

Near *E. thallophora* Meyr., but with a different arrangement of the stripes.

Arthur's Pass, in February. Two males taken by Mr. S. Lindsay and the writer. Holotype (male) in coll. S. Lindsay and a paratype in coll. Cawthron Institute.

#### OECOPHORIDAE.

##### **Borkhausenia grata** n. sp.

♂. 20–22 mm. Head and thorax light orange-yellow. Palpi light orange-yellow, second segment, except near apex, fuscous outwardly. Antennae ringed alternately with ochreous-grey and fuscous, ciliations in male  $\frac{3}{4}$ . Abdomen fuscous-grey, anal tuft ochreous. Legs whitish-ochreous, anterior pair infuscated. Forewings moderate, broad, costa moderately arched, apex bluntly pointed, termen rounded, oblique; light orange-yellow; costal margin purplish-fuscous from base to about  $\frac{1}{4}$ ; a purplish-fuscous spot on fold before middle, sometimes absent or represented only by one or two scales; a similar spot in disc at  $\frac{3}{4}$ ; fringes concolorous with wing. Hindwings light fuscous-grey; fringes light fuscous-grey, with obscure darker basal line.

The largest of the yellow group. The clear ground-colour and broader wings, apart from the male genitalic characters, distinguishes it from *B. apertella* Walk.

Dun Mountain, Nelson, from 2,000 feet to 3,000 feet, in November, December and January. Holotype (male) and several paratypes in coll. Cawthron Institute.

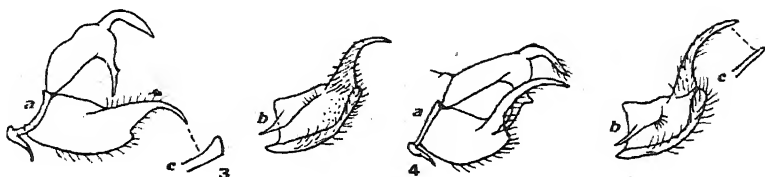


FIG. 3. *Borkhausenia enodis* n. sp. (a) Lateral view of male genitalia. (b) Inner view of harpe. (c) Apex of harpe from beneath.

FIG. 4. *Borkhausenia grata* n. sp. (a) Lateral view of male genitalia. (b) Inner view of harpe. (c) Apex of harpe from beneath.

##### **Borkhausenia enodis** n. sp.

♂. 19–20 mm. Head, palpi and thorax bright yellow, second segment of palpi, except near apex, fuscous. Antennae ringed alternately with ochreous and fuscous. Abdomen greyish-fuscous. Legs whitish-ochreous, anterior pair infuscated. Forewings, costa well arched, apex bluntly pointed, termen rounded, oblique; bright yellow; costal margin fuscous from base to about  $\frac{1}{4}$ ; fringes bright yellow. Hindwings pale greyish-fuscous; fringes greyish-fuscous with darker basal line.

Hard to distinguish from the unmarked forms of the preceding species, but the small differences in the genitalic characters seem to be quite constant while the costa is more arched and the ground colour rather paler.

Cobb Valley and localities in the vicinity of Nelson city in November and December. Holotype (male) and several paratypes in coll. Cawthron Institute. I cannot at present with certainty assign the females to either of the species just described.

***Izatha florida* n. sp.**

♂. 15-19 mm. Head, palpi and thorax black sprinkled with white. Antennae black with short grey pubescence. Abdomen black, segmental divisions yellowish-white. Legs black, tibiae and tarsi banded with white. Forewings oblong, costa arched at base, thence straight, apex rounded, termen hardly oblique; black tinged with brown and densely irrorated with bluish-white (owing to the tips of many scales being so coloured); markings formed by the elimination of the irroration; an indistinct dentate basal fascia enclosing two tufts of raised scales, one above and the other below fold, both of which contain a few yellow scales; a fairly straight fascia from  $\frac{1}{3}$  costa to  $\frac{1}{2}$  dorsum enclosing similar tufts of raised black and yellow scales; an irregular fascia, containing a few yellow scales, from  $\frac{2}{3}$  costa to tornus; fringes blackish-fuscous, basal  $\frac{1}{2}$  mixed with bluish-white. Hindwings yellow; termen and dorsum broadly dark fuscous; fringes dark fuscous.

The parti-coloured hindwings at once distinguish this handsome species.

Mount Arthur Tableland, at 4,500 feet, in November. Three males taken by the writer and Mr. W. Heighway. Holotype (male) and two paratypes in coll. Cawthron Institute.

***Izatha plumbosa* n. sp.**

♀. 20 mm. Head black sprinkled with white. Thorax black mixed with white, scutellum white, tegulae mixed with ochreous and brown. Palpi black, a broad median band and apex of second segment white, also white median band on terminal segment. Antennae black sprinkled with white basally. Abdomen black, segmental divisions white. Legs black, tibiae and tarsi banded with white. Forewings oblong, costa slightly arched, apex broadly rounded, termen rounded, little oblique; leaden grey with some ochreous and brown admixture; markings black mixed with brown; an indistinct dentate basal fascia enclosing two tufts of raised scales, one above and one below fold; a nearly straight fascia from costa at  $\frac{1}{3}$  to above dorsum at  $\frac{1}{2}$ , also enclosing raised scale tufts; an irregular fascia from costa at  $\frac{2}{3}$  to above tornus, much constricted at middle and with an indentation beneath filled with leaden grey; a terminal series of obscure dots; fringes concolorous with wing. Hindwings bronzy-fuscous; fringes fuscous with obscure basal and median pale lines.

It is possible that this may be the female of the preceding species, but having regard to the considerable differences between the two and to the widely separated localities I do not think it very probable.

Arthur's Pass, in February. The single specimen was taken near the glacier from which the Otira River has its source. Holotype (female) in coll. Cawthron Institute.

***Izatha milligani* n. sp.**

♂. 19–22 mm. Head white. Palpi white, basal and subapical bands of second segment and median and apical bands of terminal segment dark fuscous. Antennae brown with grey pubescence. Thorax white with some admixture of pale fuscous. Abdomen ochreous-whitish. Legs fuscous sprinkled with ochreous-whitish, posterior tibiae whitish-ochreous. Forewings not posteriorly dilated, costa slightly arched, apex rounded, termen rounded, oblique; white, sparsely sprinkled with pale ochreous; markings blackish-fuscous; a spot on base of costa; an elongate spot on costa at  $\frac{1}{3}$ ; a more or less triangular spot beyond  $\frac{1}{2}$ ; a suffused terminal shade; two elongate spots in disc and sometimes a third below first on fold; fringes grey. Hindwings and fringes pale fuscous-grey.

Nearest to *I. apodoxa* Meyr. but quite differently marked.

Leigh, North Auckland, in January. Five males sent by Mr. D. D. Milligan. Holotype (male) and two paratypes in coll. Cawthron Institute.

***Atomotricha lewisi* n. sp.**

♂. 23–24 mm. Head and thorax dull brown mixed with grey. Palpi with terminal segment much shorter than second, ochreous-whitish mixed with brown externally. Antennae annulated alternately with ochreous-whitish and dark fuscous, ciliations in male 5. Abdomen dull brassy-yellow, segmental divisions whitish and some fuscous on basal segments. Legs ochreous-whitish, more or less infuscated. Forewings, costa moderately arched, apex rounded, termen oblique; dull brown; sometimes a broad stripe of ochreous-white along dorsum, tapering to tornus and triangularly indented above near base, also a suffused stripe of the same colour beneath costa to about  $\frac{3}{4}$ ; fringes whitish-ochreous with three or four lines of brown points. Hindwings and fringes ochreous-whitish sprinkled with brown.

The male genitalia show this species to be most nearly related to *A. isogama* Meyr.

Two males received from the late Mr. J. H. Lewis; locality of capture probably Central Otago. Holotype (male) and a paratype in coll. A. Philpott.

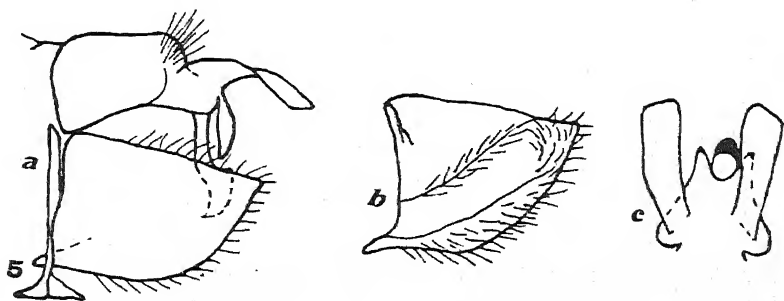


FIG. 5. *Atomotricha lewisi* n. sp. (a) Lateral view of male genitalia. (b) Inner view of harpe. (c) Obliquely dorsal view of uncus and gnathos.

*Barea exartha* (Meyr.), *Proc. Linn. Soc. N.S.W.*, vol. 8 (1st ser.), p. 357; *Izatha planetella* Huds., *Ent. Mo. Mag.*, vol. 59, p. 218.

A specimen of this Australian species was reared by Mr. A. Tonnoir, of the Canterbury Museum, from a larva found feeding on the decayed portion of an imported hardwood pole. The moth, a female, emerged in November. It appears probable that this species has established itself in the Canterbury district, as Mr. S. Lindsay has sent me a male taken by him at Dean's Bush, Christchurch, in February of this year. The type of *planetella* was thought to be from Ohakune, in the centre of the North Island, in no way an improbable locality in view of the larval habits.

***Eutorna inornata* n. sp.**

♂ ♀. 12–14 mm. Head ochreous-whitish. Palpi ochreous-whitish, apex of terminal segment brown. Antennae fuscous, annulated with ochreous, basally ochreous. Thorax pale ochreous. Abdomen ochreous-whitish. Legs ochreous-whitish, anterior pair infuscated. Forewings with the branches of the first cubitus short-stalked, costa moderately arched, apex pointed, termen oblique; ochreous mixed with white; a blackish-fuscous spot, usually elongate, at about  $\frac{1}{3}$ ; a black dot in disc at  $\frac{2}{3}$ ; fringes ochreous. Hindwings greyish-fuscous; fringes ochreous.

Easily distinguished from *E. symmorpha* Meyr., apart from the venational difference, by the comparative lack of markings. It has not been considered advisable to base a new genus on the venational detail noted, the other characters being normal.

Seaward Moss (Invercargill), in January (Philpott). Bottle Lake and Waikuku (Canterbury), in November and March (Heighway and Lindsay). Holotype (male) and allotype (female) in coll. A. Philpott. Two paratypes in coll. Cawthron Institute.

GLYPHIPTERYGIDAE.

***Glyphipteryx necopina* n. sp.**

♂ ♀. 11–15 mm. Head and thorax ochreous-white. Palpi with small triangular tuft beneath, ochreous-white, indistinctly barred with pale fuscous. Antennae brown. Abdomen pale brassy, in male dorsally dark fuscous. Legs whitish, anterior pair fuscous and posterior pair annulated with dull fuscous. Forewings narrow, costa moderately arched, apex, in male rounded, in female acute, termen strongly oblique; in male ochreous-white, paler along costa, in female white; an interrupted blackish-fuscous streak from about  $\frac{1}{4}$  to apex, frequently represented only by a few dots, in female more constantly present; a black spot or spots above tornus; in female three or four interrupted blackish-fuscous transverse fasciae on apical  $\frac{1}{4}$ ; fringes whitish-ochreous with prominent blackish median line and blackish tips round apex. Hindwings shining grey-whitish; fringes pale ochreous.

*G. necopina* belongs to the *ataracta* group, but differs from its allies, in addition to the markings, by the smaller palpal tuft.

Golden Downs and Gordon's Nob, in January. Common among the rough herbage on marshy ground in the valley, and on the dry scanty vegetation of the mountain at 3,000 feet.

GRACILARIIDAE.

**Gracilaria purpurea** n. sp.

♂ ♀. 14-15. Head and thorax dark ochreous-brown, with a purplish-violet sheen, face white. Palpi ochreous-brown. Antennae ochreous closely annulated with brownish. Abdomen (missing). Forewings brassy-yellow, densely covered with purplish-violet strigulae which show a tendency to form spots at  $\frac{1}{3}$ ,  $\frac{2}{3}$ , and  $\frac{1}{2}$ ; fringes greyish-fuscous, concolorous with wing round apex. Hindwings leaden-grey; fringes brownish-fuscous.

Somewhat resembling *G. linearis* Butl. but without the triangular pale costal area of that species.

West Plains, near Invercargill, date uncertain. Holotype (male) and allotype (female) in coll. A. Philpott.

PLUTELLIDAE.

**Orthenches nivalis** n. sp.

♀. 17 mm. Head white. Papi white, outwardly mixed with fuscous. Antennae white, annulated with blackish fuscous. Thorax white, tegulae mixed with pale fuscous. Abdomen greyish-white. Legs, anterior and middle pair fuscous, posterior pair white. Forewings, costa moderately arched, apex round-pointed, termen rounded, oblique; white with scattered strigulations of leaden-fuscous; markings purplish-fuscous; some irregular spots round base of tornus; a large blotch at  $\frac{1}{3}$  covering middle third of wing, preceded and touched by a round spot on fold; an oblique inwardly directed mark in disc at middle; an obscure irregular spot at  $\frac{2}{3}$ ; fringes white mixed with fuscous, obscurely barred round apex. Hindwings and fringes shining white.

Easily distinguished by the markings from the other whitish species of the genus.

Arthur's Pass, in February. A single male (holotype) in coll. Cawthron Institute.

NEPTICULIDAE.

**Nepticula insignis** n. sp.

♂. 5-6 mm. Head white, sometimes ochreous tinged. Antennae fuscous, eye-cap whitish. Thorax ochreous. Abdomen dark fuscous. Forewings white with much admixture of ochreous, especially on basal portion and in disc; a black spot on fold at  $\frac{1}{4}$ , sometimes absent; a prominent black spot in disc at  $\frac{1}{2}$ , usually elongate; a black spot, large or small, before apex; fringes fuscous-grey with several rows of ochreous points round apex and termen. Hindwings and fringes fuscous-grey.

Mount Arthur Tableland, at 4,000 feet, in November. Three males taken. Holotype (male) and paratypes in coll. Cawthron Institute.

TINEIDAE.

**Mallobathra cana** n. sp.

♂. 14-15 mm. Head and thorax ochreous-brown. Antennae ochreous, ciliations in male 3. Abdomen fuscous-brown. Legs

fuscous mixed with ochreous, posterior pair more ochreous, all tarsi annulated with ochreous. Forewings elongate-triangular, costa moderately arched, apex round-pointed, termen strongly oblique; ochreous, covered with brown strigulae and with strong purplish-violet iridescence; the strigulae tend to form spots on apical half of costa and round termen; an indistinct brown spot on dorsum at  $\frac{1}{2}$ ; fringes fuscous mixed with ochreous. Hindwings and fringes greyish-fuscous with purplish-violet sheen.

More like a *Taleporia* in shape and coloration, but structurally a *Mallobathra*.

Dun Mountain, in December. Two males taken at 3,500 feet. Holotype (male) and a paratype in coll. Cawthron Institute.

### *Mallobathra tonnoiri* n. sp.

♂. 16 mm. Head, thorax and abdomen blackish-fuscous. Antennae blackish-fuscous, ciliations in male  $2\frac{1}{2}$ . Forewings, costa moderately arched, subsinuate, apex rounded, termen oblique; dark brownish-fuscous obscurely strigulated with ochreous; an undefined patch of paler ochreous on dorsum near base; a large spot of whitish-ochreous on dorsum beyond middle; fringes dark purplish-fuscous. Hindwings and fringes dark fuscous with purplish sheen.

Close to *M. strigulata* Philp. and *M. fenwicki* Philp., but without the dark dorsal blotch of the former, and a larger and darker species than the latter.

Lake Moana, in December. A single male taken by Mr. A. Tonnoir. Holotype (male) in coll. Canterbury Museum.

## MICROPTERYGIDAE.

### *Sabatinca heighwayi* n. sp.

♀. 13.5 mm. Head covered with dense long hair reaching beyond  $\frac{1}{2}$  of antennae, light tawny. Antennae bright brown, tips black. Thorax tawny, densely long-haired. Abdomen dark fuscous. Legs ochreous, tarsi banded with fuscous. Forewings long, costa strongly arched at base, apex round-pointed, termen very oblique; shining brassy; fasciae ivory-yellow with pink reflections; three equidistant complete curved fasciae between base and  $\frac{1}{2}$ ; at  $\frac{3}{4}$  a fascia interrupted below middle; between  $\frac{1}{2}$  and  $\frac{3}{4}$  a fascia indicated by marks on costa and dorsum; two fasciae near apex, broadly interrupted at middle; all fasciae are here and there margined with blackish; an obscure reddish shade commences in disc at third fascia and runs to apex; fringes pinkish-brown obscurely barred with pale yellow. Hindwings metallic violet, paler near base; fringes fuscous with some yellow at middle of termen.

Structurally nearest to *S. lucilia* Clarke and *S. calliarcha* Meyr., R1 of the hindwing being complete.

Leslie Valley, Mount Arthur Tableland, in November. Two females taken by Mr. W. Heighway. Holotype (female) and slides of wings and female genitalia in coll. Cawthron Institute.

## The Modification of the Eighth Sternite in *Microdes* (Lepidoptera).

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera,  
Cawthron Institute, Nelson.

[Read before the Nelson Philosophical Institute, 27th July, 1926; received  
by Editor, 30th July, 1926; issued separately,  
10th August, 1927.]

It is not very unusual to find the eighth abdominal segment in the Lepidoptera modified to a greater or lesser degree. In the Micropterygidae the sternite of this segment may be absent (*Sabatinca*), or represented by a narrow strip only (*Microyteryx*); in Hepialidae it takes the form of a rather flat well chitinised plate lying beneath the vinculum, while in some Geometrids (*Acidaliinae*) the whole segment is irregular in shape and frequently armed with lateral processes (cerata of Pierce), or the segment may be more normal but have a variously shaped more strongly chitinised median area (*Eupitheciinae*). These, and similar departures from the normal, are usually confined to the male sex and are almost certainly connected with the act of pairing.

In *Microdes*, a small genus confined to New Zealand and Australia, a very interesting structure is to be found. I have been able to examine the males of six species of the genus and it proved to be well developed in each. Pierce (the Genitalia of the British Geometridae) has described and figured this modified eighth sternite in the *Eupitheciinae*, the group to which *Microdes* belongs, and it appears that the structure assumes a considerable variety of forms; none of these, however, is quite similar to *Microdes* though *Calliclystis* approaches fairly near. As long ago as 1891 Dr. Buchanan White drew attention to the differences in the terminal segments of the males of *Eupithecia*. He described (*Entomologist*, vol. 24, p. 129) more than thirty species, each showing marked differences in the "ultimate" (eighth) sternite, and, in some instances, in the "penultimate" (seventh) also.

The male genitalia of *Microdes* are normally completely withdrawn into the eighth segment which (see fig. 1), is greatly produced dorsally. The ventral portion of the eighth sternite is somewhat flattened and bears a forcipate structure, the base of which rests on the anterior margin, while the tips of the prongs project just beyond the posterior edge of the sclerite. This organ, for which I suggest the name "lyra," is apparently a development of the sternite itself, being formed simply by stronger chitinisation. It will be seen from the figures, which are of the same magnification, that the lyra provides a very good specific character, at least for those forms which have been available for examination.

In what manner the lyra functions it is difficult to imagine. Its position on the eighth sternite would seem to prevent it from participation in conjunction with the extruded parts of the ninth segment; nor do the genitalia of the female show any unusual external features which might suggest adaptation to the male structure.

*Microdes epicryptis* Meyr. and *M. quadristrigata* Walk. are New Zealand species; the others are from Australia. I have pleasure in expressing my best thanks to Mr. G. V. Hudson for material of *M. epicryptis* and to Dr. A. J. Turner and Mr. G. Lyell for the Australian insects.

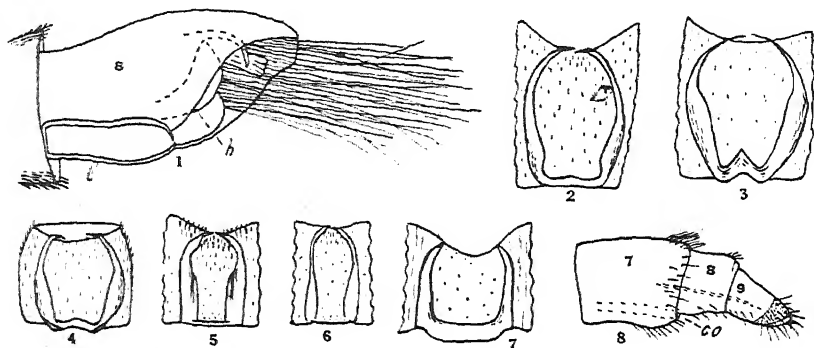


FIG. 1.—*Microdes squammulata* Guen. Obliquely lateral view of male genitalia in normal position. 8, eighth segment; h, harpes; 1, lyra.

FIG. 2.—*M. squammulata* Guen. Eighth sternite, ventral view.

FIG. 3.—*M. dipodonta* Turn. Eighth sternite, ventral view.

FIG. 4.—*M. oreochares* Turn. Eighth sternite, ventral view.

FIG. 5.—*M. villosata* Guen. Eighth sternite, ventral view.

FIG. 6.—*M. quadristrigata* Walk. Eighth sternite, ventral view.

FIG. 7.—*M. epicryptis* Meyr. Eighth sternite, ventral view.

FIG. 8.—*M. villosata* Guen. Apical segments of female. 7, 8 and 9, seventh, eighth and ninth segments; co, copulatory opening.

## The Male Genitalia of the New Zealand Tineidae.

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera,  
Cawthron Institute, Nelson.

[Read before the Nelson Philosophical Society, 3rd November, 1926; received  
by Editor, 5th November, 1926; issued separately,  
10th August, 1927.]

Writing in 1914, Mr. E. Meyrick (2) listed 46 species of Tineidae as occurring in New Zealand, and though at the present date 73 species are recognised, the family still remains rather poorly represented. Several species, semidomestic in habit, have been artificially introduced, but leaving these aside, we find that endemic forms largely preponderate, there being 15 endemic genera out of a total of 20. Eyer (1) states that the Tineidae "forms the basis for practically all of the types of genitalia which occur in the Tineoidea." As far as the inference of variety goes this is applicable to the New Zealand Tineidae; genitalia structure of the simplest kind characterises some of the genera, while in others the most specialised and complicated organs are present. What is still more remarkable is that in some instances, these two extremes are to be found within the same genus. Under these circumstances, and having regard to the fragmentary character of the group here dealt with, it would serve little practical purpose to attempt a diagnosis of the genitalia characters of the family. But it may be said that usually the gnathos is imperfect (not fused) or absent, the juxta absent or small, the harpes broad, entire or with a narrow sacculus and the aedeagus, which may be straight or curved, usually long and thin.

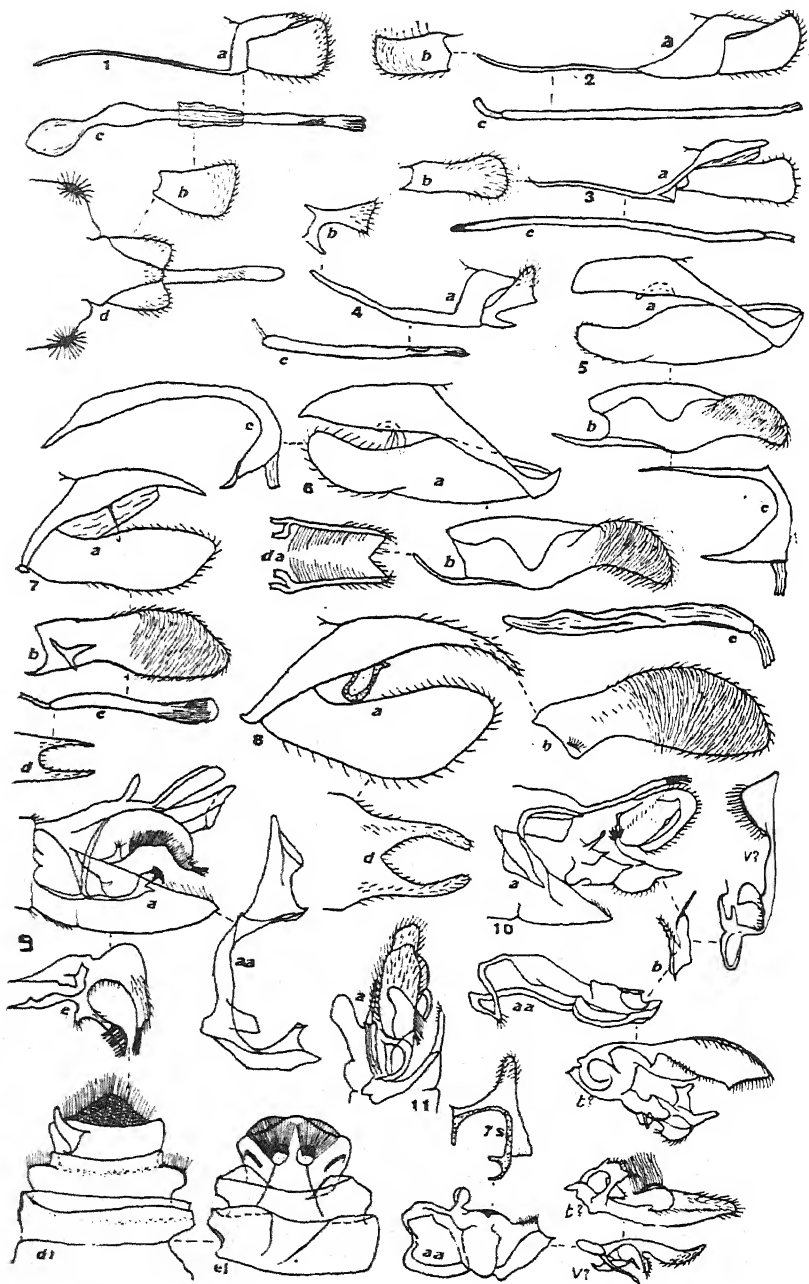
In the case of several species lack of material has prevented examination, and it must be remembered that any conclusions arrived at are subject to such limitations. Figures of the various parts in all of the species investigated are given.

### **Endophthora** (Fig. 1.)

A small endemic genus containing three species. Only one of these, *E. omogramma* Meyr. has been examined. The genitalia are of simple type. Uncus moderate, apex rounded; tegumen fused with vinculum, saccus very long and thin; gnathos and juxta absent; harpes broad, entire, dilated apically; aedeagus linear, somewhat bulbous basally. The most specialised character is the elongate saccus. On each side of the eighth tergite, near the caudal margin, is a radiating tuft of spines, probably functioning in some way in connection with reproduction.

### **Crypsitricha** (Figs. 2-4.)

An endemic genus, allied to the preceding, containing six species. The same general description will apply, but the aedeagus is not markedly bulbous basally and in at least one species, *C. stereota* Meyr. the harpes are divided into two lobes.



FIGS. 1-11.

**Archyala** (Figs. 5–8.)

Endemic. Five species have been described, four of which are here dealt with. Uncus long, bifid or bilobed; tegumen fused with vinculum, saccus small; gnathos a pair of weak lobes not fused apically; harpes long, entire; aedeagus curved, sometimes hooked basally.

**Sagephora** (Figs. 9–12.)

Endemic. Five species. The genitalia\* are extraordinarily modified, the specialisation extending to the seventh segment, which is divided along the pleural area, the tergite assuming the function of an uncus and the sternite suggesting a fused pair of harpes. The tergite may be broad or narrow, its length being sometimes increased by a dense apical tuft of hair; the sternite is sometimes asymmetrical. Within the seventh segment, which is soft and more or less membranous, lies the eighth, which may take the form of an irregular asymmetrical ring or band bearing several processes, or be modified into a pair of structures placed in opposition to each other laterally. These structures are of the most complicated and involved nature though not unfitted to act as harpes, the function of which they probably undertake. The very much reduced and altered ninth segment is enclosed in turn by the eighth. Its normal constituents are, for the most part, quite unrecognisable, though vestigial harpes can usually be made out. The aedeagus was not observed and is apparently a simple membranous duct. The whole structure of the genitalia is difficult to understand and there is much variation between the different species, but it seems fairly certain that the ninth segment with its appendages—that is, the normal genitalia of other lepidoptera—is here reduced to comparatively unimportant form and function, that the eighth segment largely takes the place of the ninth, and that the seventh assists the eighth in its unusual capacity. Altogether, the genitalia characters of this small genus are among the most extraordinary and interesting in the whole of the lepidoptera.

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\* For correction in the interpretation of the parts in this genus see end of article.

(Lettering: a, genitalia, lateral view; aa, modified eighth segment; b, harpe; bf, reduced harpes and juxta; c, aedeagus; cb, base of aedeagus; d, uncus, dorsal view; da, uncus, ventral view; df, terminal segments of abdomen of female, dorsal view; e, transtilla; ef, terminal segments of abdomen of female, ventral view; f, juxta; g, abdomen, lateral view; t, tegumen; v, vinculum; vc, vinculum, caudal view; 7s, seventh sternite; 7t, seventh tergite; 8s, eighth sternite; 8t, eighth tergite.)

FIG. 1.—*Endophthora omogramma* Meyr.

FIG. 2.—*Crypsitricha mesotypa* Meyr.

FIG. 3.—*C. roseata* Meyr.

FIG. 4.—*C. stereota* Meyr.

FIG. 5.—*Archyala opulenta* Philp.

FIG. 6.—*A. terranea* Butl.

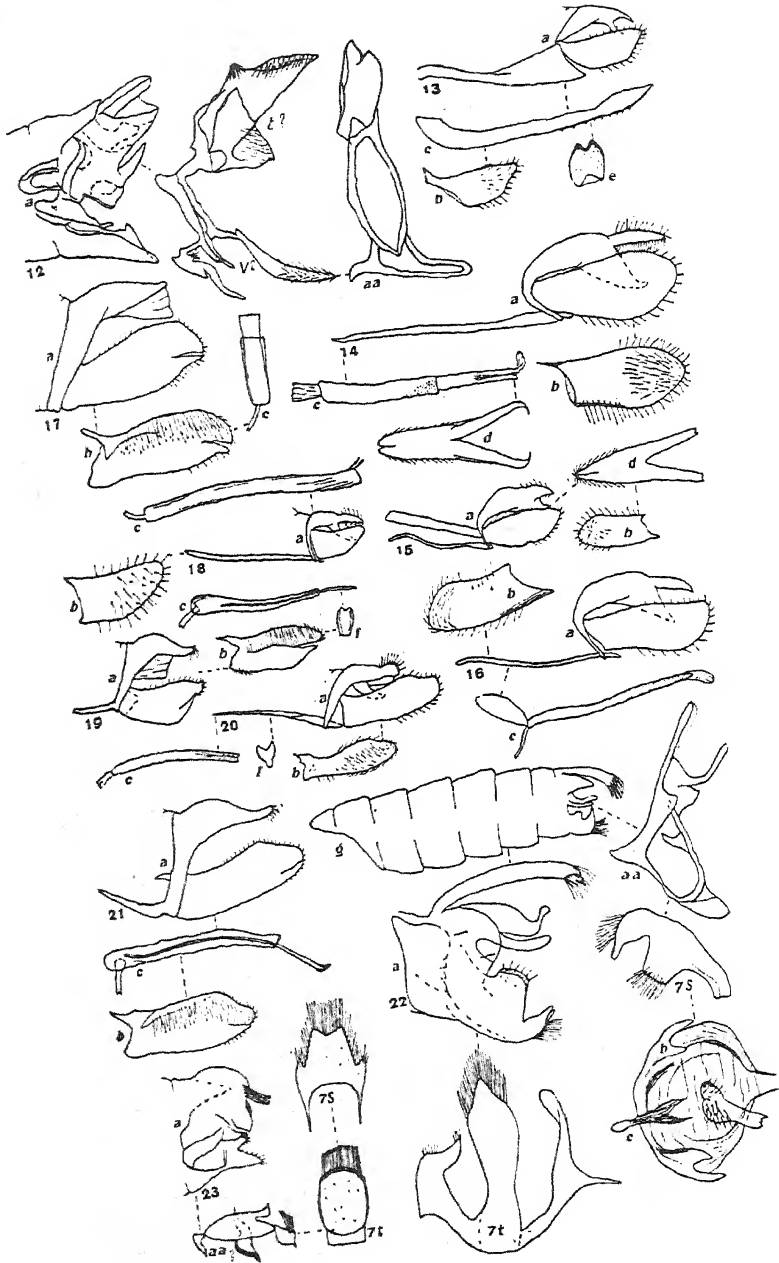
FIG. 7.—*A. paraglypta* Meyr.

FIG. 8.—*A. pentazyga* Meyr.

FIG. 9.—*Sagephora phortegella* Meyr.

FIG. 10.—*Sagephora exsanguis* Philp.

FIG. 11.—*S. felix* Meyr.



FIGS. 12-23.

Though the consideration of the female genitalia does not come within the range of this article, it will not be out of place to draw attention to the terminal abdominal segments of the female of *S. phortegella* Meyr. (fig. 9, df and ef.), particularly the finger-like process on the right dorsal area of the ninth tergite. Doubtless the irregular and asymmetrical form here displayed has an important connection with the unusual character of the organs of the male.

### Trichophaga (Fig. 13.)

An introduced species, *T. tapetiella* L., is the only representative. Gnathos partially fused; tegumen and vinculum not fused, saccus long, broad on caudal half; harpes entire; juxta absent; transtilla present and of a shape frequently assumed by the juxta; aedeagus long, armed with short barbs on apical half.

### Monopis (Figs. 14–16.)

Four species occur, one of which, *M. typhlopa* Meyr., is confined to the Chatham Islands; the cosmopolitan *M. crocicapitella* Clem. has been accidentally introduced. Gnathos a pair of broad lateral plates, not fusing apically; the arms of the tegumen pass right round the body and fuse beneath the saccus, that is, the elongate saccus here represents the whole of the vinculum; harpes entire, broad; aedeagus long, straight, tube-like.

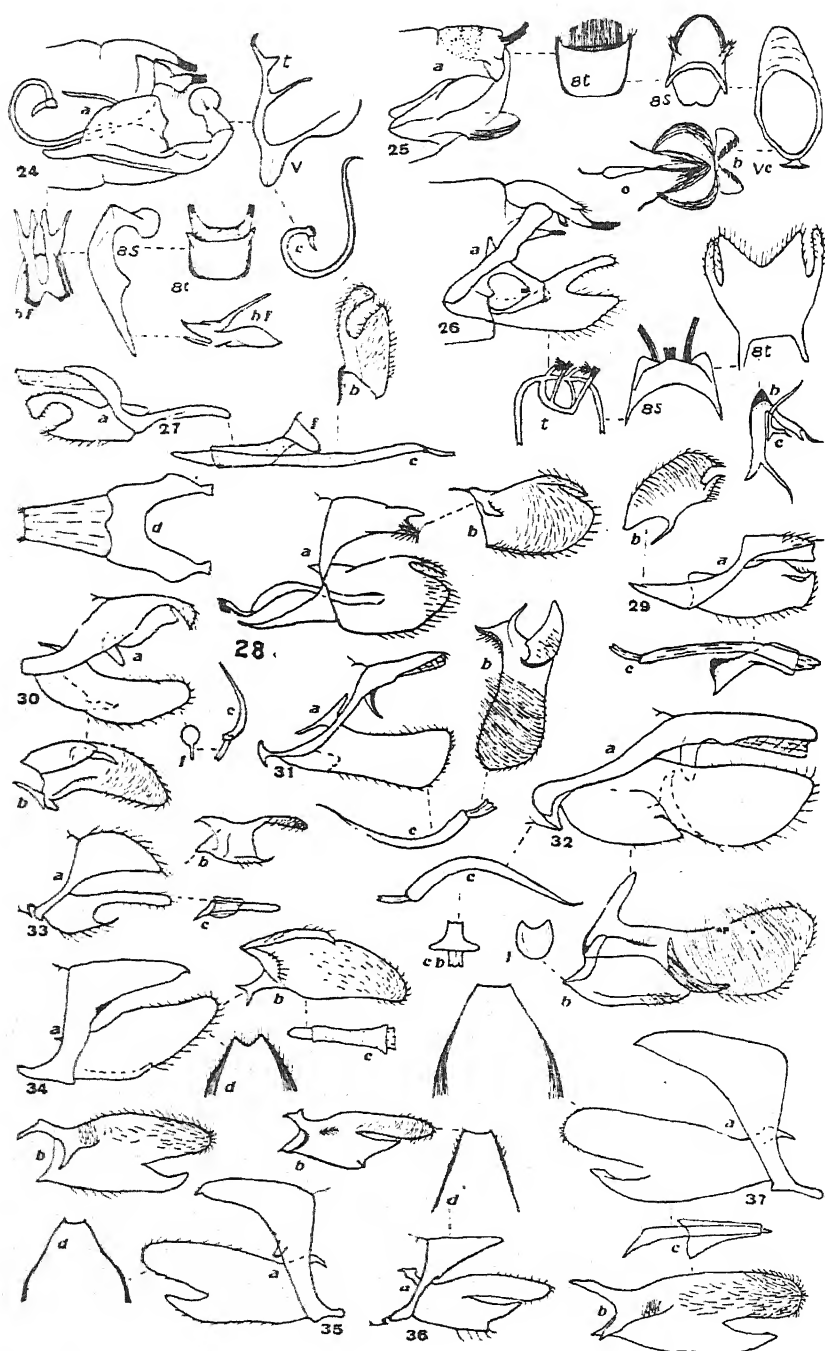
### Tinea (Figs. 17–26.)

Fifteen species have been recorded, including three introduced forms. It is necessary to divide the genus into two sections, one of which, "A," has comparatively simple genitalia, while the other, "B," exhibits extremely specialised parts.

A. Gnathos frequently absent, but may be well developed and the arms strongly connected though not fused; tegumen and vinculum fused, saccus usually well developed, absent in *T. fagicola* Meyr.; harpes entire or cleft; juxta small or absent; aedeagus long, tube-like, short in *T. fagicola*.

B. In this section the eighth segment is greatly modified, so that it takes an important part in the genitalia characters. The tergite is produced and bears a dense apical tuft (or tufts) of hair; it may also have irregular lateral processes. The sternite is usually broad, with a pair of lateral lobes, but it may be asymmetrical. The tegumen and vinculum are fused, much altered and variable; the harpes are

- 
- FIG. 12.—*S. steorpastis* Meyr.  
 FIG. 13.—*Trichophaga tapetiella* L.  
 FIG. 14.—*Monopis ethelella* Newm.  
 FIG. 15.—*M. crocicapitella* Clem.  
 FIG. 16.—*M. ornithias* Meyr.  
 FIG. 17.—*Tinea fagicola* Meyr.  
 FIG. 18.—*T. pellationella* L.  
 FIG. 19.—*T. cymodoce* Meyr.  
 FIG. 20.—*T. mochlotia* Meyr.  
 FIG. 21.—*T. astraea* Meyr.  
 FIG. 22.—*T. accusatrix* Meyr.  
 FIG. 23.—*T. margaritis* Meyr.



FIGS. 24-37.

vestigial. The aedeagus is usually thin, sharp and curved, sometimes almost s-shaped.

**Prothinodes** (Fig. 27.)

Endemic. Two species. Gnathos absent. Tegumen broad apically, fused with vinculum, anal tube projecting much beyond uncus and with small dorso-lateral tufts of hair at apex, saccus fairly long; harpes deeply and widely cleft; juxta present; aedeagus long, straight.

**Proterodesma** (Fig. 28.)

Endemic. Monotypic. Gnathos not fused; tegumen and vinculum not fused, vinculum moderately long; harpes broad, with finger-like cucullus; aedeagus moderately long, sinuate.

**Trithamnora** (Fig. 29.)

Endemic. Monotypic. Gnathos absent; tegumen and vinculum fused, saccus moderate; harpes with shallow cleft, cucullus narrow; juxta present, but appears to be a modification of the anellus; aedeagus moderate, curved.

**Lysiphragma** (Figs. 30–32.)

Endemic. Three species. Gnathos present, not fused; uncus long, tegumen and vinculum fused, saccus small; harpes with large basal ventral fold; juxta small; aedeagus rather short, curved, thin, pointed.

**Lindera.**

One introduced Australian species. The peculiar genitalia have been already fully described (3) in *Proc. Linn. Soc. N.S.W.* vol. 50, p. 32.

**Taleporia** (Figs. 33–35.)

Three New Zealand species are known. Gnathos absent or very small; tegumen broad, fused with vinculum, saccus small; harpes with small sacculus; juxta absent, a false juxta formed by fold, armed with spines, near base of harpes; aedeagus small, finger-like.

**Mallobathra** (Figs. 36–45.)

Endemic. Thirteen species. Gnathos usually a simple band, sometimes chitinized laterally only, in some species apparently absent;

FIG. 24.—*T. dicharacta* Meyr.

FIG. 25.—*T. argodelta* Meyr.

FIG. 26.—*T. sphenocosma* Meyr.

FIG. 27.—*Prothinodes grammocosma* Meyr.

FIG. 28.—*Proterodesma byrsophila* Meyr.

FIG. 29.—*Trithamnora certella* Walk.

FIG. 30.—*Lysiphragma howesi* Quail

FIG. 31.—*L. mixochlora* Meyr.

FIG. 32.—*L. epixyla* Meyr.

FIG. 33.—*Taleporia cawthronella* Philp.

FIG. 34.—*T. aphrosticha* Meyr.

FIG. 35.—*T. scoriota* Meyr.

FIG. 36.—*Mallobathra cana* Philp.

FIG. 37.—*M. crataea* Meyr.

uncus with apex truncate or slightly indented; tegumen fused with vinculum, saccus small, in *M. illustris* Philp. moderate; harpes cleft, in *M. homalopa* Meyr. sacculus again cleft; juxta absent; aedeagus short or moderate.

**Scoriodyta** (Fig. 46.)

Endemic. Monotypic. Gnathos absent but closing membrane modified to form a pair of large leaf-like projecting flaps and a stiff plate beneath, the rectum passing behind these; tegumen and vinculum fused, saccus very small; harpes consisting of an outer weakly chitinised flap and an inner stronger one densely studded with short stout spines; juxta absent; aedeagus short, irregular.

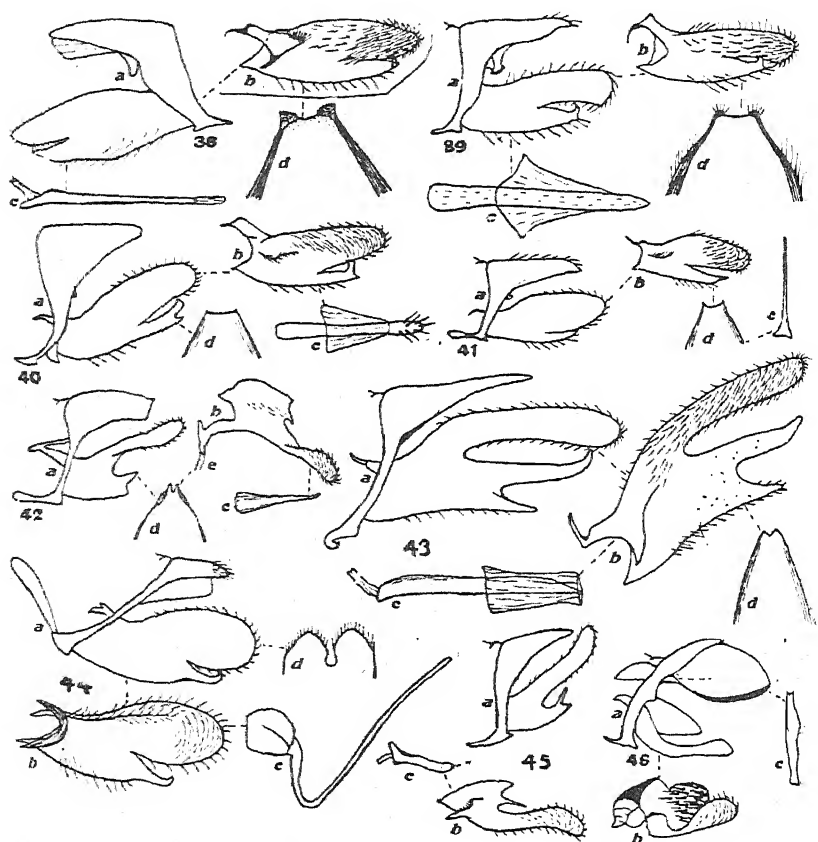


FIG. 38.—*M. strigulata* Philp.  
 FIG. 39.—*M. perriscura* Meyr.  
 FIG. 40.—*Mallobathra fenwicki* Philp.  
 FIG. 41.—*M. metrosema* Meyr.  
 FIG. 42.—*M. fragilis* Philp.  
 FIG. 43.—*M. homalopa* Meyr.  
 FIG. 44.—*M. illustris* Philp.  
 FIG. 45.—*M. arancosa* Meyr.  
 FIG. 46.—*Scoriodyta conisalia* Meyr.

Correction: A study of the male genitalia of the Lyonetiidae has shown me that the interpretation given above of the extremely specialised parts in *Sagephora* is incorrect. As, however, the blocks for the plates were already made it seemed best to allow the text to stand and to submit here the explanation of the structures as now understood. The following description should therefore be substituted for that given in the body of the paper.

### *Sagephora* (Figs. 9–12.)

Endemic. Five species. The genitalia are extraordinarily modified, the specialisation extending to the seventh segment, the sternite of which forms a large concave plate embracing the organs from beneath. In some species, as *S. felix* Meyr., a basal framework, more strongly chitinised than the remaining portion, has been developed. The eighth sternite similarly, but not so completely, envelops the parts from above. Tegumen asymmetrical, the apical portion an irregular strongly chitinised plate. Vinculum much reduced, fused with tegumen to form a ring. Eighth sternite a very irregular U-shaped piece, the apices, which are attached to the vinculum, ending in two prongs. In some species the right arm of the sternite is not bifid or forked, but ends in a single point, thus making the organ asymmetrical. A somewhat similar form of the eighth sternite is found in *Lindera tessellatella* Blanch., but the position of the organ is entirely different. Harpes extremely complicated in form and quite unlike each other, the left being much larger than the right and consisting of an outer convex plate which embraces a very intricate inner structure. Aedeagus attached to right harpe, short and thick, irregularly rounded basally, apically becoming finely pointed and with a thin secondary process.

It will be necessary also to note the consequent emendations in the lettering of the figures (9, 10, 11 and 12) of the species concerned. Thus aa = tegumen and vinculum; b = part of right harpe; c = left harpe; t? = left harpe (in *S. exsanguis* an obliquely lateral view with the two portions forced apart); v? = right harpe and eadeagus. The opportunity also serves to point out a further error; 7t and 7s in the figures of *Tinea accusatrix* and *T. margaritis* should be respectively 8t and 8s.

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2. MEYRICK, E., Revision of the New Zealand Tineina, *Trans. N.Z. Inst.*, vol. 47, p. 205, 1915.
3. PHILPOTT, A., On a remarkable Modification of the Eighth Abdominal Segment in *Lindera tessellatella* Blanch. *Proc. Linn. Soc. N.S.W.*, vol. 50, p. 32, 1925.

## The Male Genitalia of the New Zealand Oecophoridae.

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[Read before the Nelson Philosophical Society, 30th June, 1926; received by  
Editor, 2nd July, 1926; issued separately,  
10th August, 1927.]

THE family Oecophoridae is numerically a very important one among New Zealand micro-lepidoptera, its members comprising about one-third of the whole of the Tineoidea. This predominance is chiefly due to the large genus *Borkhausenia* which, in turn, accounts for nearly forty per cent. of the Oecophoridae. Other fairly large genera are *Gymnobathra* (14 species) and *Izatha* (18 species), both of which are endemic, and *Trachypepla* (19 species), which has several representatives in Australia. The remaining forms are divided among about twenty genera and constitute either small endemic groups or are outliers of genera more common elsewhere. At least two species, *Endrosis lucteella* Schiff. and *Borkhausenia pseudospretella* Stt., are semi-domestic in habits and have undoubtedly been accidentally introduced by man.

### OTHER PUBLICATIONS DEALING WITH THE GENITALIA OF THE FAMILY.

The male genitalia of the family have been dealt with, in part, in previous publications. These are as follows:—

- “List of New Zealand Species of *Borkhausenia* (Oecophoridae: Lepidoptera), including New Species.” *Trans. N.Z. Inst.*, vol. 56, p. 399. This article figures the male genitalia of 47 species of the genus.
- “New Zealand Lepidoptera: Notes and Descriptions.” *Trans. N.Z. Inst.*, vol. 56, p. 387. Gives figures of the male genitalia of *Borkhausenia affinis* Philp., *B. terrena* Philp., *Euchersadula tristis* Philp., *E. lathriopa* (Meyr.), *Leptocroca scholaea* (Meyr.), *L. asphaltis* (Meyr.), *L. variabilis* Philp., *L. vacua* Philp. and *Barea ambigua* Philp.
- “The Genitalia of the Genus *Gymnobathra*.” *Trans. N.Z. Inst.* vol. 57, p. 716. Figures the male genitalia of all species except *G. philadelphia* Meyr., *G. thetodes* Meyr. and *G. sarcantha* Meyr.
- “New Zealand Lepidoptera: Notes and Descriptions.” *Trans. N.Z. Inst.*, vol. 57, p. 703. Figures the male genitalia of *Borkhausenia marcida* Philp. and *B. paula* Philp.

### GENERAL DESCRIPTION OF THE MALE GENITALIA.

A general description of the male genitalia in each genus follows, with keys to the species in the larger groups. These keys, with

the figures, will probably be found sufficient for species determination without detailed descriptions. From want of material the genera *Aochleta* (one species) and *Philobota* (two species) have had to be omitted.

**Schiffermuelleria** Huebn. (Fig. 1).

Only a single straggler, *S. orthophanes* Meyr., is found in New Zealand. The male genitalia are of fairly normal *Oecophorid* type, the chief modification being the long narrow basally-projecting process (saccus) of the vinculum. The uncus is of moderate length and is opposed by a normal gnathos, the apical projection of which is directed caudally. The harpes are irregularly oblong and divided into a cucullus and sacculus, the latter being the more strongly chitinised and having its apex overlapping the former.

**Endrosis** Hübn. (Fig. 2).

The world-wide house-frequenting species, *S. lacteella* Schiff. is the only form found in New Zealand. The tegumen, with its uncus and gnathos, resembles that of the preceding species. The harpes are of simple leaf-like type, with the ventral margin forming apically a free curved lobe. It is doubtful if such a lobe, which occurs frequently among the *Oecophoridae*, can be regarded as the homologue of the sacculus, a part which rather seems to be the result of an apical splitting of the harpe. As in the preceding species, the vinculum is produced in a cephalic direction, but is here very broad and scoop-like. The juxta consists of two long tapering lobes springing from the basal plate. The unusual development of the vinculum and juxta is probably related to the corresponding development of the aedeagus, which is both stout and long, reaching almost from the base of the vinculum to the apex of the harpe.

**Chersadaula** Meyr. (Fig. 51).

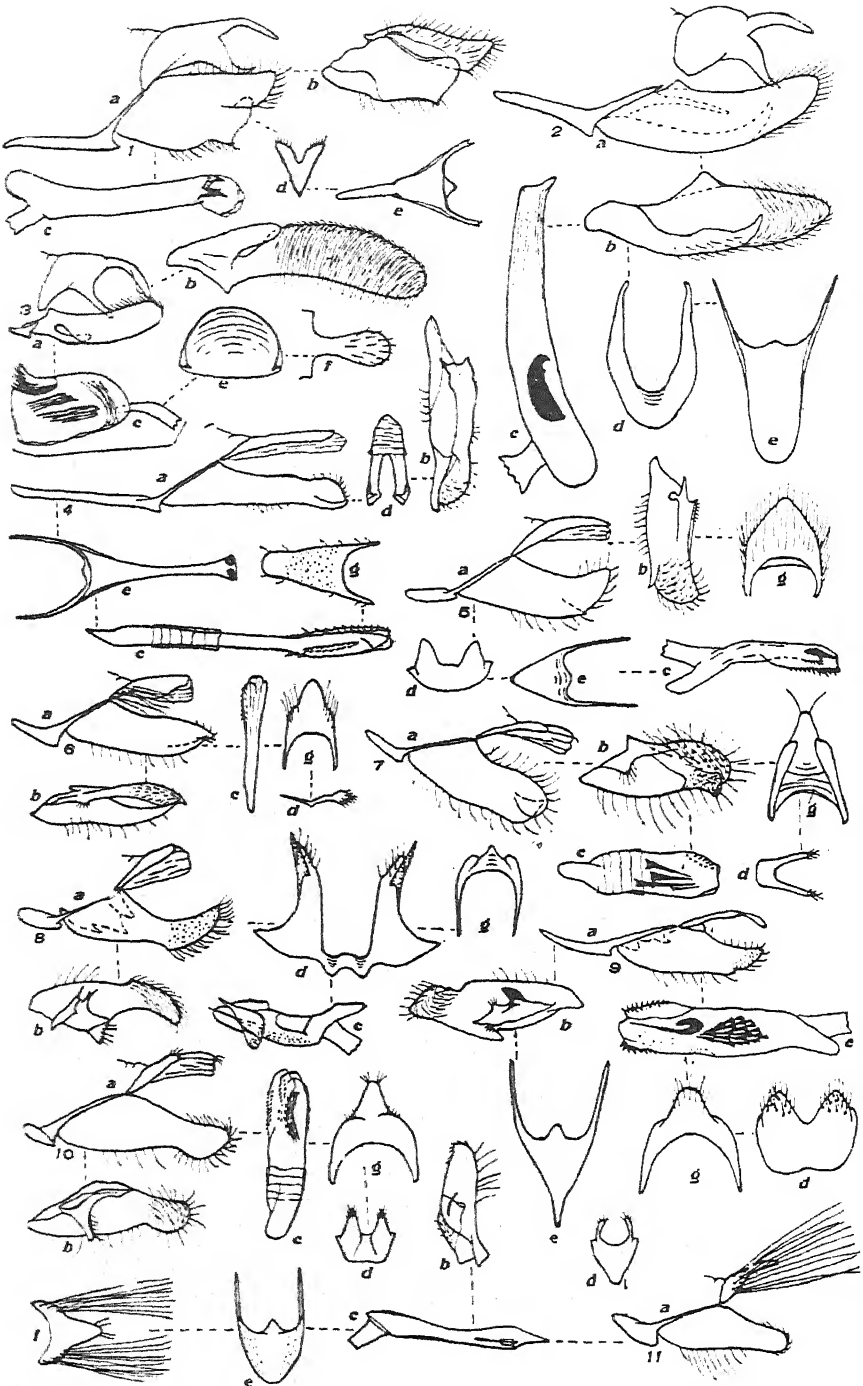
Monotypic and endemic. The ♂ genitalia show affinity with the *chloradelpha* group of *Borkhausenia*, the chief difference being that in *C. ochrogastra* Meyr. the harpes are clothed outwardly with long hair-scales.

**Thamnosara** Meyr. (Fig. 3).

Monotypic and endemic. The genitalia resemble those of some species of *Gymnobathra*; *Barea dinocosma* Meyr. and *B. ambigua* Philp. also exhibit the same type. The uncus is apically dilated and bears some spiny areas near its abruptly truncate apex.

**Izatha** Walk. (Figs. 4 to 18).

The genus is characterised by the feeble development of the tegumen and uncus, the anal tube frequently projecting beyond the apex of the latter. The gnathos is absent. The harpes, in a few instances, are divided into sacculus and cucullus, but in outline do not depart much from the *Oecophorid* type. On the inner side near the base is a process which takes a variety of forms in the different species. It is probably a development of the editum, which in *Borkhausenia* and other related genera consists only of a slight fold



FIGS. 1—11.

clothed with a few short hairs. The juxta invariably mainly consists of a pair of processes, which may range from a blunt protuberance, as in *I. epiphanes* Meyr. to a long and irregular cone, as in *I. peroneanella* Walk. The aedeagus, in most instances, has an elaborate armature of spines, which may be short or long, single or arranged in rows or groups. In view of the specialisation of the other parts the absence of the gnathos and the weakness of the uncus may be considered to be also the result of specialisation.

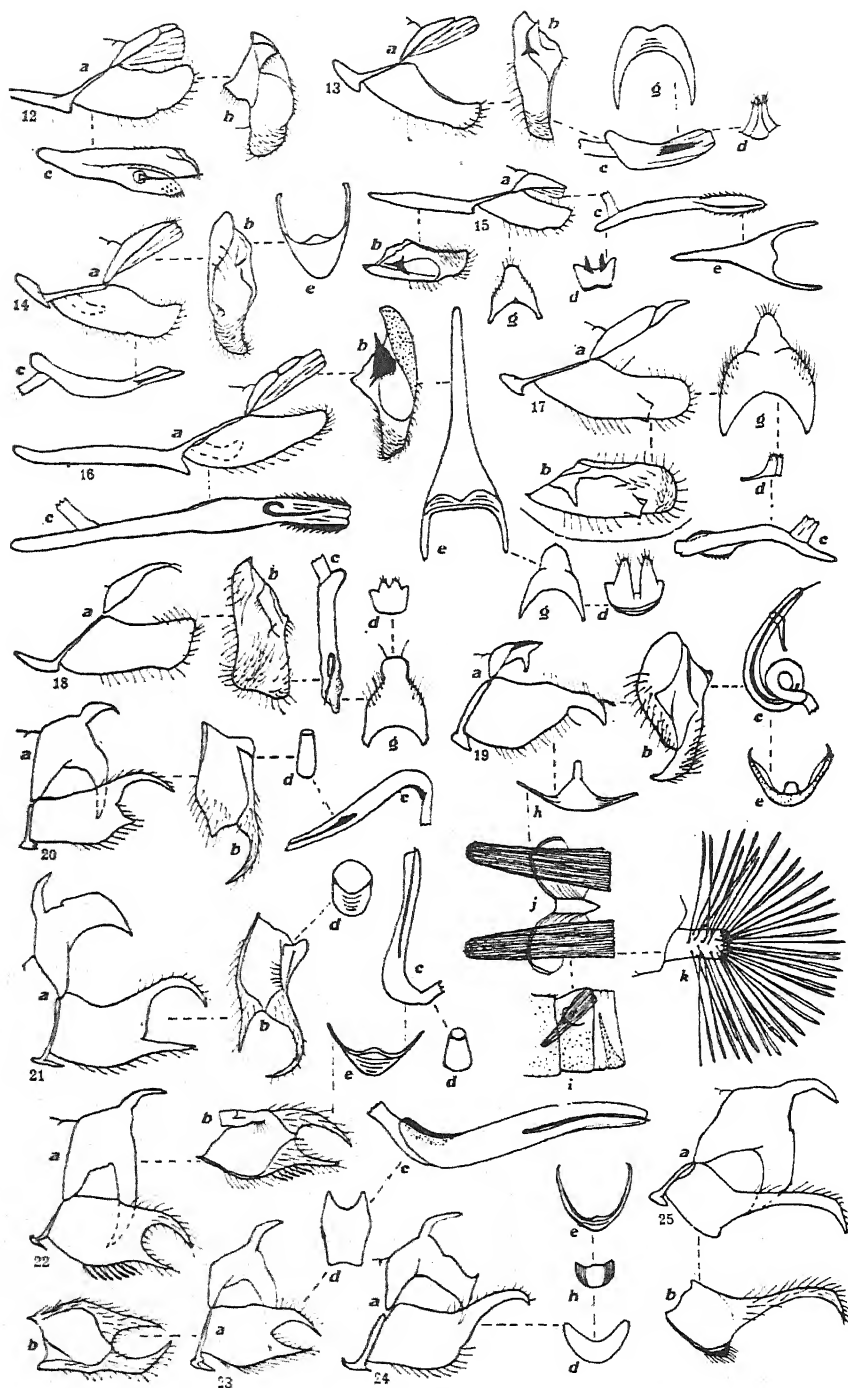
KEY TO THE SPECIES OF *IZATHA*.

1. Harpes with apical fissure or lobe .....	2
Harpes without apical fissure or lobe .....	5
2. Vinculum very long .....	<i>amorbas</i> Meyr.
Vinculum not long .....	3
3. Juxta with lobes short and broad .....	<i>convulsella</i> Walk.
Juxta with lobes short and narrow .....	4
4. Juxta with lobes clavate .....	<i>mira</i> Philp.
Juxta with lobes pointed .....	<i>metadelta</i> Meyr.
5. Harpes with apex narrowed .....	6
Harpes with apex not narrowed .....	14
6. Juxta with apex of lobes bifid .....	<i>peroneanella</i>
Juxta with apex of lobes not bifid .....	7
7. Apex of harpes acute .....	<i>epiphanes</i> Meyr.
Apex of harpes not acute .....	8
8. Apex of harpes broadly rounded .....	9
Apex of harpes not broadly rounded .....	11
9. Apex of harpes dilated .....	<i>atactella</i> Walk.
Apex of harpes not dilated .....	10
10. Apex of aedeagus long-pointed .....	<i>prasophyta</i> Meyr.
Apex of aedeagus blunt, more or less truncate .....	<i>austera</i> Meyr.
11. Vinculum short .....	12
Vinculum long .....	13
12. Lobes of juxta with apex pointed .....	<i>huttoni</i> Butl.
Lobes of juxta with apex truncate .....	<i>phaeoptila</i> Meyr.
13. Harpes with indentation on ventral margin at $\frac{1}{4}$ .....	<i>picarella</i> Walk.
Harpes without indentation on ventral margin .....	<i>apodora</i> Meyr.
14. Harpes with apical margin rounded .....	<i>caustopa</i> Meyr.
Harpes with apical margin nearly straight .....	<i>balanophora</i> Meyr.

The male genitalia of *I. acmonias* Philp. differ little, if at all, from those of *I. picarella* Walk. and the former species may be only a large race of the latter. I have not found, however, any intermediate

(Lettering: a, male genitalia, lateral view; b, harpe—inner view; c, aedeagus—in some instances the juxta is included; d, juxta, ventral view; e, vinculum; f, uncus, in some instances showing the gnathos also; g, tegumen, dorsal view; h, transtilla; l, apex of gnathos.)

- FIG. 1.—*Schiffermuelleria orthophanes* Meyr.  
 FIG. 2.—*Endrosis lacteella* Schiff.  
 FIG. 3.—*Thamnosara sublitella* Walk.  
 FIG. 4.—*Izatha amorbas* Meyr.  
 FIG. 5.—*Izatha convulsella* Walk.  
 FIG. 6.—*Izatha mira* Philp.  
 FIG. 7.—*Izatha metadelta* Meyr.  
 FIG. 8.—*Izatha peroneanella* Walk.  
 FIG. 9.—*Izatha epiphanes* Meyr.  
 FIG. 10.—*Izatha atactella* Walk.  
 FIG. 11.—*Izatha prasophyta* Meyr.



FIGS. 12-25.

individuals and it is advisable, for the present, to recognise the two species. Of *I. manubriata* Meyr., *I. planetella* Huds. and *I. copiosella* Walk. I have not been able to obtain material for dissection.

### **Locheutis** Meyr. (Fig. 19).

The single New Zealand representative (*L. vagata* Meyr.) of this genus is remarkable for the reduction of the tegumen, which is very small in comparison with the normal sized harpes. The gnathos is present, but is very weakly chitinised. A  $\perp$ -shaped transtilla connects the upper basal angles of the harpes, an organ not usually present in the family. A structure on the seventh tergite probably has relation to the genitalia. It is a paired organ, situated caudally on the dorso-lateral region, and is in the form of a pouch filled with long hair-scales. This pouch can be everted, when it becomes a truncate finger-like process with the long hairs standing out in all directions, though most numerous round the apex. The eighth segment is largely membranous, there being only a narrow chitinised strip in a median position on the sternite.

### **Trachypepla** Meyr. (Figs. 20 to 31).

This genus closely approaches *Borkhausenia* in genitalia characters. The gnathos is strongly developed, the uncus finger-like from a lateral view and the harpes with both cucullus and sacculus, or cucullus only. The aedeagus is a simple tubular organ, enclosing a slender spine-like penis and supported beneath by a small shield-shaped or rounded concave juxta.

#### KEY TO THE NEW ZEALAND SPECIES OF *TRACHYPEPLA*.

1. Harpes with both cucullus and sacculus .....	2
Harpes with cucullus only .....	5
2. Sacculus at least half as long as cucullus .....	3
Sacculus less than half as long as cucullus .....	<i>hieropis</i> Meyr.
3. Costa of harpes deeply sinuate .....	<i>anastrella</i> Meyr.
Costa of harpes not deeply sinuate .....	4
4. Lower angle of juxta rounded .....	<i>euryleucota</i> Meyr.
Lower angle of juxta rectangular .....	<i>conspicuellu</i> Walk.
5. Gnathos curved downward .....	6
Gnathos curved upward .....	11
6. Frontal plate of gnathos produced upward .....	<i>aspidephora</i> Meyr.
Frontal plate of gnathos not produced upward .....	7

FIG. 12.—*Izatha austera* Meyr.

FIG. 13.—*Izatha huttonii* Butl.

FIG. 14.—*Izatha phaeoptila* Meyr.

FIG. 15.—*Izatha picarella* Walk.

FIG. 16.—*Izatha apodoxa* Meyr.

FIG. 17.—*Izatha caustopa* Meyr.

FIG. 18.—*Izatha balanophora* Meyr.

FIG. 19.—*Locheutis vagata* Meyr. i, seventh segment, showing pouch containing brush of long hair-scales; j, dorsal view of paired pouches on seventh segment; k, a pouch everted, forming a finger-like process carrying a brush of radiating hairs.

FIG. 20.—*Trachypepla hieropis* Meyr.

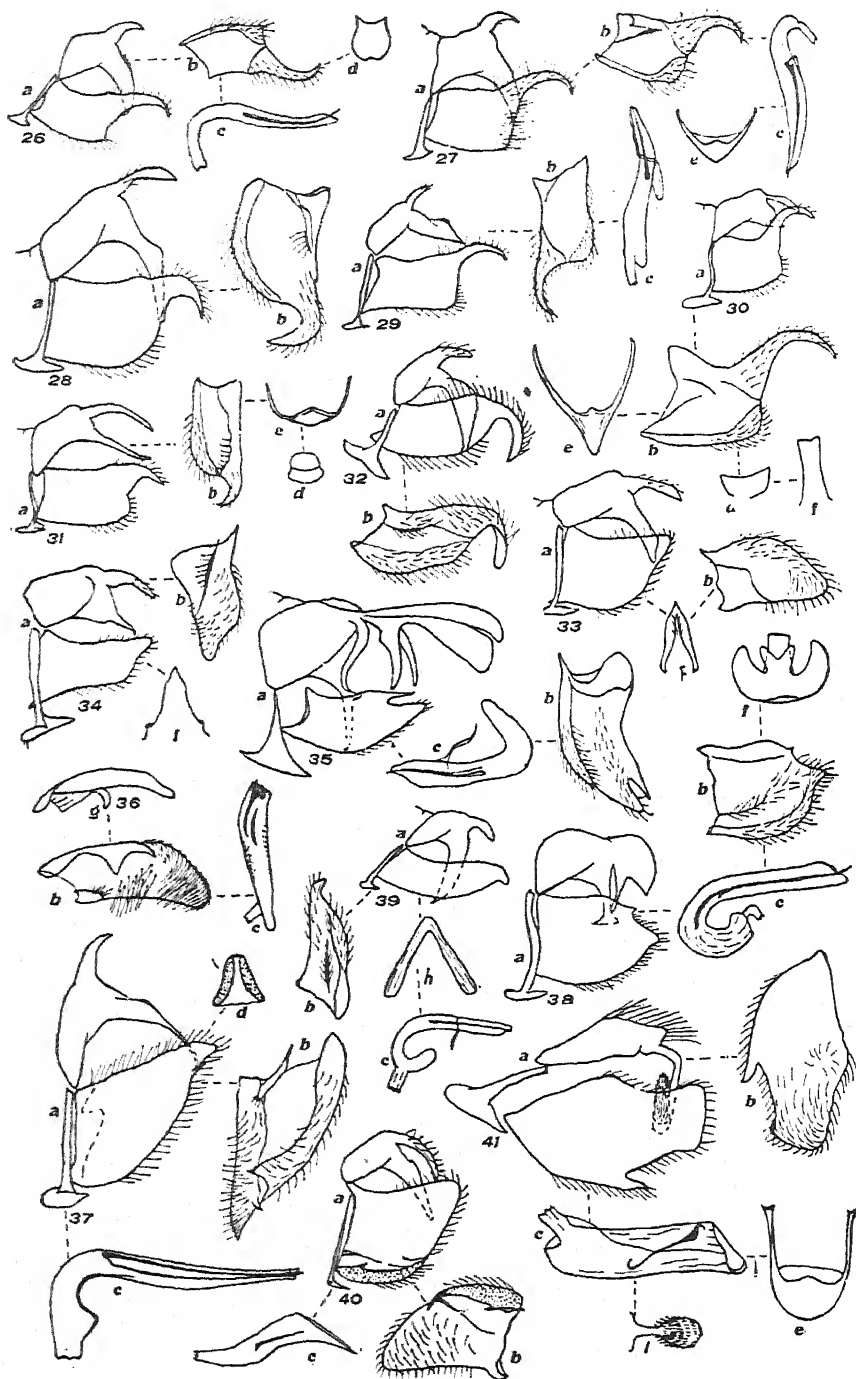
FIG. 21.—*Trachypepla anastrella* Meyr.

FIG. 22.—*Trachypepla euryleucota* Meyr.

FIG. 23.—*Trachypepla conspicuella* Walk.

FIG. 24.—*Trachypepla aspidephora* Meyr.

FIG. 25.—*Trachypepla ingenua* Meyr.



FIGS. 26-41.

7.	Cucullus about as long as, or longer than, main portion of harpe .....	8
	Cucullus shorter than main portion of harpe .....	10
8.	Cucullus considerably longer than main portion of harpe .....	<i>ingenua</i> Meyr.
	Cucullus about as long as main portion of harpe.....	9
9.	Ventral angle of harpes rectangular .....	<i>protochlora</i> Meyr.
	Ventral angle of harpes rounded .....	<i>galaxias</i> Meyr.
10.	Cucullus broad and strongly curved .....	<i>leucoplanetis</i> Meyr.
	Cucullus narrow and gently curved .....	<i>contritella</i> Walk.
11.	Cucullus long and narrow .....	<i>lichenodes</i> Meyr.
	Cucullus short and broad .....	<i>semilauta</i> Philp.

Six of the eighteen species have not been available for dissection and *T. phaeoptila* Meyr. proves, on examination, to belong to *Izatha*.

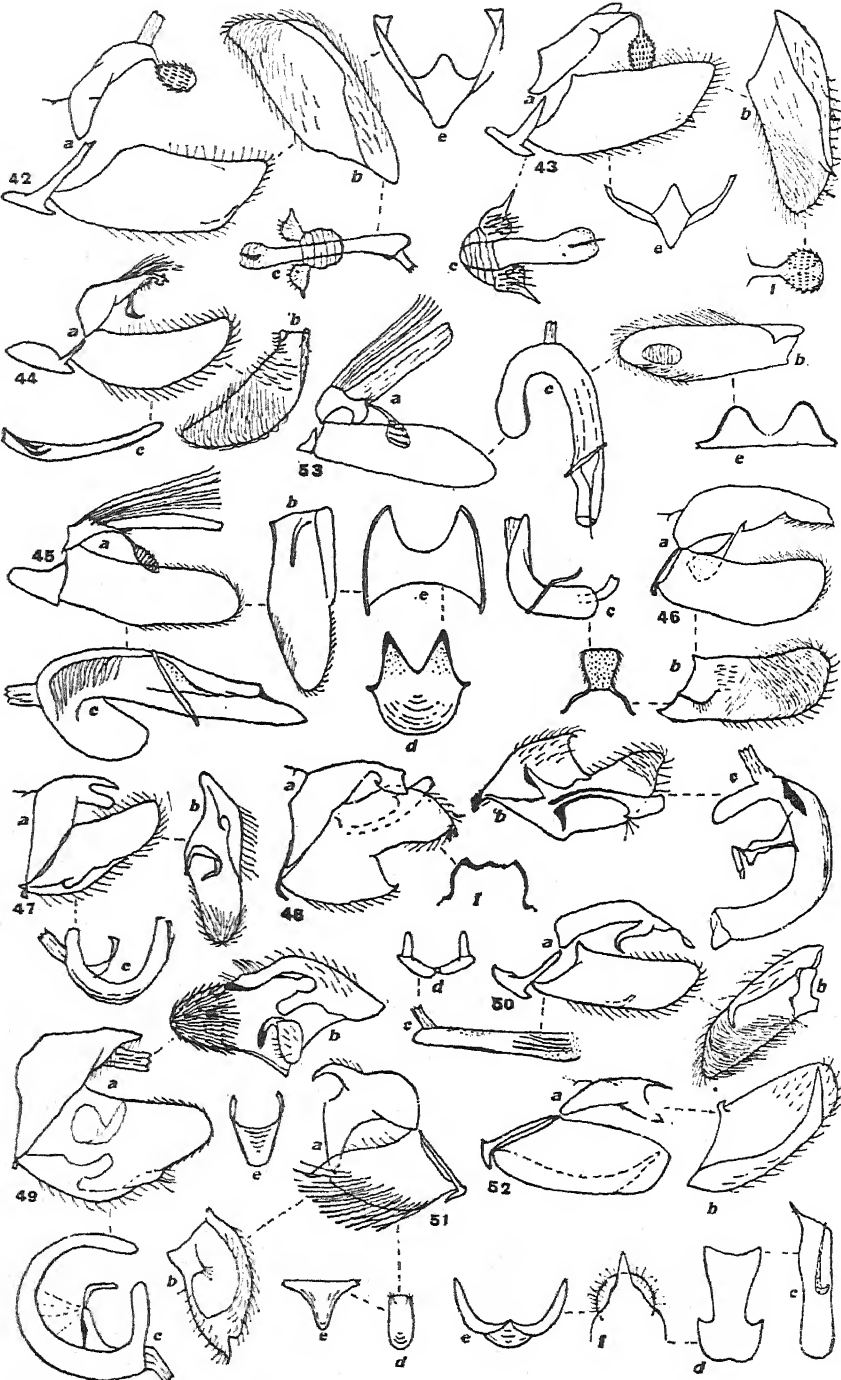
### **Euthictis** Meyr. (Fig. 32).

Only one species, *E. chloratma* Meyr., of this small Australian genus is known from New Zealand. The genitalia of the male approach those of *Trachypepla*.

### **Atomotricha** Meyr. (Figs. 33, 34, 35 and 38).

The male genitalia in *Atomotricha* display, in some cases, very striking specific differences. In others, however, the differences are not of sufficient importance to warrant specific distinction. It is possible that *A. versuta* Meyr., *A. chloronota* Meyr. and *A. sordida* Butl. may be only forms of one widely spread species; they cannot be separated by definite genitalia characters. *A. exsomnia*, Meyr., though nearer than any of the other species examined to this group, is at once distinguished by the broad uncus and altogether differently shaped gnathos. So far there is no departure from the more simple Oecophorid types, but the remaining two forms, which are all I have been able to examine, are extremely specialised. In *A. isogama* Meyr. the uncus is divided into two elongate paddle-shaped blades, from near the base of each of which a long process projects above the gnathos. The gnathos is strongly developed and the front of the ring is curved prominently upward. The harpes are much narrowed apically where they are cleft into two portions. *A. ommatias* Meyr. is somewhat of the same type, but the uncus is divided into two depressed rounded flat oblique plates, the lateral arms being

- 
- FIG. 26.—*Trachypepla protochlora* Meyr.  
 FIG. 27.—*Trachypepla galaxias* Meyr.  
 FIG. 28.—*Trachypepla leucoplanetis* Meyr.  
 FIG. 29.—*Trachypepla contritella* Walk.  
 FIG. 30.—*Trachypepla lichenodes* Meyr.  
 FIG. 31.—*Trachypepla semilauta* Philp.  
 FIG. 32.—*Euthictis chloratma* Meyr.  
 FIG. 33.—*Atomotricha versuta* Meyr.  
 FIG. 34.—*Atomotricha exsomnia* Meyr.  
 FIG. 35.—*Atomotricha isogama* Meyr.  
 FIG. 36.—*Barea dinocosma* Meyr.  
 FIG. 37.—*Barea confusella* Walk.  
 FIG. 38.—*Atomotricha ommatias* Meyr.  
 FIG. 39.—*Eulechria zophoessa* Meyr.  
 FIG. 40.—*Oxythecta austrina* Meyr.  
 FIG. 41.—*Nymphostola galactina* Feld.



FIGS. 42-53.

smaller and nearer the gnathos than in *A. isogama*; the frontal process of the gnathos is also much shorter. The apical fissure of the harpes in *A. isogama* is here represented by a wide indentation.

There being considerable doubt as to the validity of several of the species, no key is at present attempted.

**Barea** Walk. (Figs. 36 and 37).

Of the three New Zealand species of this genus, two, *B. dinocosma* Meyr. and *B. ambigua* Philp., have genitalia of the *Gymnobathra* type; the remaining species, *B. confusella* Walk., approaches more nearly to some forms of *Borkhausenia*. The harpes, however, exhibit a character not found in the latter genus, the ventral fold being free at its apex and developing into a pointed process. There is also a somewhat similar process beyond, arising from the dorsal area and projecting slightly over the ventral margin.

#### KEY TO THE NEW ZEALAND SPECIES OF *BAREA*.

- |  |                         |
|--|-------------------------|
| 1. Gnathos depressed; hook-shaped .....                | 2                       |
| Gnathos not depressed; without hook .....              | <i>confusella</i> Walk. |
| 2. Ventral lobe of harpes with median projection ..... | <i>dinocosma</i> Meyr.  |
| Ventral lobe of harpes without median projection ..... | <i>ambigua</i> Philp.   |

**Eulechria** Meyr. (Fig. 39).

The single New Zealand species, *E. zophoessa* Meyr., of this extensive genus shows the normal characters of the family, with the exception that a fairly well-developed A-shaped transtilla is present.

**Oxythecta** Meyr. (Fig. 40).

This Australian genus has one representative, *O. austrina* Meyr. in New Zealand. The uncus and gnathos are of normal type, but the harpes exhibit some unusual features. The ventral margin is very strongly chitinised and the fold within, in addition to a free apical lobe, has a pointed process at about  $\frac{1}{2}$  from base. The aedeagus is dilated at its apex and obliquely truncate; basally it passes imperceptibly into the ductus ejaculatorius.

**Parocystola** Turner. (Fig. 52).

The only New Zealand representative of this large Australian genus is *P. acroxantha* Meyr., a comparatively recent addition to our lepidopterous fauna. The male genitalia of this species do not differ greatly from those of *Gymnobathra* as far as the vinculum, tegumen and harpes go, but the rounded gnathos and peculiar juxta are distinctive.

FIG. 42.—*Proteodes profunda* Meyr.

FIG. 43.—*Proteodes carnifer* Butl.

FIG. 44.—*Compsistis bifasciella* Walk.

FIG. 45.—*Eutorna caryochroa* Meyr.

FIG. 46.—*Cryptolechia semnodes* Meyr.

FIG. 47.—*Cryptolechia compsotypa* Meyr.

FIG. 48.—*Cryptolechia apocrypta* Meyr.

FIG. 49.—*Cryptolechia liochroa* Meyr.

FIG. 50.—*Lathicrossa leucocentra* Meyr.

FIG. 51.—*Chersadaula ochrogastra* Meyr.

FIG. 52.—*Parocystola acroxantha* Meyr.

FIG. 53.—*Eutorna symmorphia* Meyr.

**Nymphostola** Meyr. (Fig. 41).

A monotypic and endemic genus. The uncus has almost disappeared and consists only of a rounded prominence behind the base of the gnathos. The gnathos itself is highly specialised, the frontal plate taking the form of a scoop-like expansion, outwardly thickly covered with backwardly directed short spines. The harpes are broad, apically truncate, and with a small thumb-like projection beyond the middle of the ventral margin. The aedeagus is rather short and stout.

**Proteodes** Meyr. (Figs. 42 and 43).

A small endemic genus containing three species. The uncus and gnathos are of the same type as those of the preceding genus, but the harpes are more normal in shape. Reference to the figures will show the very distinctive characters of the aedeagus and juxta. No difficulty will be found in separating *P. profunda* Meyr. and *P. carnifex* Butl., but a male of *P. clarkei* Philp. has not been available for dissection.

**Compsistis** Meyr. (Fig. 44).

The single New Zealand species, *C. bifasciella* Walk., of this South American genus is characterised by the peculiar bifid and laterally expanded uncus. The gnathos is rather weak with the frontal plate upcurved; the harpes are of simple leaf-like type.

**Eutorna** Meyr. (Figs. 45 and 53).

The outstanding feature of the male genitalia of the two New Zealand species of this genus is the complete absence of the uncus, the long anal tube being protected by a tuft of hair springing from the dorsal surface of the tegumen. The gnathos is very highly specialised. From near the apex of each lateral arm arises a racket-shaped organ of the same nature as the single structure of *Proteodes*. The harpes are simple in type and the cephalic margin of the vinculum is deeply and widely excised.

KEY TO THE NEW ZEALAND SPECIES OF *EUTORNA*.

Gnathos with frontal plate; vinculum small .....	.....	<i>symmorpha</i> Meyr.
Gnathos without frontal plate; vinculum large .....	.....	<i>caryochroa</i> Meyr.

**Cryptolechia** Z. (Figs. 46 to 49).

Of the six New Zealand species of *Cryptolechia* two have not been available for examination. Of the remaining four, three, *C. apocrypta* Meyr., *C. compsotipa* Meyr. and *C. hochroa* Meyr. form a related group, but the fourth, *C. semnodes* Meyr. differs very considerably. The group just referred to is characterised by the absence of the gnathos, the development of processes on the inner surface of the harpes, the reduction of the vinculum to a narrow band and the strongly curved aedeagus. In *C. hochroa* the curving of the aedeagus is carried so far that the base and apex almost meet.

In *C. semnodes* the harpes are simple, but the gnathos is present; it consists of a pair of thin lateral arms and a broad flat frontal plate covered with minute spines.

KEY TO THE NEW ZEALAND SPECIES OF *CRYPTOLECHIA*.

- |  |                         |
|--|-------------------------|
| 1. Gnathos present .....                         | 2                       |
| Gnathos absent .....                             | <i>compsotypa</i> Meyr. |
| 2. Tegumen with paired lateral projections ..... | 3                       |
| Tegumen without paired lateral projections ..... | <i>apocrypta</i> Meyr.  |
| 3. Uncus broadly expanded laterally .....        | <i>liochroa</i> Meyr.   |
| Uncus not expanded laterally .....               | <i>semnodes</i> Meyr.   |

**Lathicrossa** Meyr. (Fig. 50).

Monotypic and endemic. The genitalia of *L. leucocentra* Meyr. approach nearer to the type of *Barea dinocosma* Meyr. than to any of the New Zealand representative of the Oecophoridae.

## Biological Notes on the Copepod *Boeckella triarticulata*.

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ALTHOUGH the animal which forms the subject of the present paper belongs to a family (Centropagiae) with numerous fresh-water as well as marine representatives, the family belongs to the Calanid group of Copepoda, which has very few other fresh-water representatives but is characteristically an open-sea group; in accordance with this mode of life, the animals are adapted in various ways for vigorous activity in the water. The anterior antennae for example, which are the chief swimming-organs, are extremely long and powerful, and the other appendages are well provided with muscles and setae. In these respects they contrast with other Copepoda, such as the littoral Harpacticoida, the fresh-water Cyclopids, and the parasitic forms. The fresh-water Centropagiae retain the chief characteristics of the Calanid group, the main tendency in the case of *Boeckella* and its relatives being a reduction in the number of joints and setae of the fifth feet of the male.

*Boeckella triarticulata* is the type species and genus of the Boeckellidae, the counterpart of *Diaptomus* of the northern hemisphere; over thirty species are known from New Zealand, Tasmania, the southern parts of Australia and South America, and from Kerguelen's Land. *Boeckella triarticulata* is known from New Zealand and the south-eastern corner of Australia; three other species of related genera have also been reported from New Zealand, but a more detailed account of these and some further recently-collected species is reserved for a later paper.

*Boeckella triarticulata* was originally described by the Hon. G. M. Thomson in 1882 from specimens collected by Dr. Chilton, and a fuller account was later given by Sars (*Videnskabs-Selskabets Skrifter*. 1-Mathem. Naturv. Klasse, 1894, No. 5). Brady, commenting on the collection of Copepoda from New Zealand Lakes made by Messrs. Hodgkin and Lucas (*Proc. Zool. Soc.*, London, 1906, p. 696) says that *Boeckella* "seems to be the commonest of all the lacustrine Copepoda of New Zealand." This refers to the cold lakes of the mountainous regions; the present writer has also taken the species in abundance from many localities throughout the Canterbury Plains from Cheviot to beyond Waimate, and finds it equally abundant from those lower levels. It is absent from streams, except backwaters which are so filled with weeds as to be almost still; but it is nearly always to be found in stagnant pools, especially those which do not dry up during the summer. The writer has rarely taken it without *Cyclops*, and never without Ostracods; when found at all it is generally present

in abundance. It is probably the commonest species of Copepod, though *Cyclops* is the commonest genus, and not infrequently taken without *Boeckella*, especially in slowly-running water; but in swifter water *Cyclops* also is absent, its place being taken by the Amphipod *Paracalliope fluviatilis*.

The aim of the present paper is to record some observations on the living animal, and especially the movements of the appendages, with an attempt to explain the significance of those movements and to point out some relations between structure and function. It is to be regretted that while among the Copepoda so much is known of the dead body, so little is known of the living animal; the difficulties in the way of such studies are lessened in the case of *Boeckella*, for the animal is common, comparatively large, frequently conspicuously coloured, easily cultivated, and docile under the microscope. Similar studies with other species and with *Diaptomus* would be of considerable interest.

*The Colour.*—Sars (i.e., pp. 50, 54, 56) says that the female is transparently bluish, with red markings, while the male is more pronouncedly red. The writer's observations show that while this is accurate as far as it goes, there is much variation in the colour; specimens from any one pond adhere fairly strictly to a definite colour-scheme, but there is a wide range of variability from different sources; this, however, probably does not imply that there are distinct strains, as the colour seems to depend on age and environmental circumstances, and the related genus *Diaptomus* is known to be very variable.

In some cases adult males and females of *Boeckella* are almost pure white as seen against a black background, the only colour being the red of the eye; but nearly always the genital area of the female is bright red, and the region around the mouth is usually red in both sexes. When the colour-scheme is more elaborate, a comparison of specimens of different sizes from the same locality indicates that the deposition of pigments is in the order named—eye, genitalia, mouth, and though other parts may become coloured these three regions always remain the most intensely pigmented. Sometimes the remaining coloration in the case of the female (possibly in semi-mature specimens only) is a diffused blue throughout the body; but usually the predominant colour is reddish-brown. This appears at an early stage in the dorsal parts of the second, third, and fourth body-segments, and in the posterior foot-jaws; most other parts of the body follow suit, especially the rest of the thorax, the remaining mouth-parts, anterior antennae, and anal furcae, the colour being faintest on the front part of the head, bases of the first antennae, the abdomen (except the furcae, and the genitalia of the female), and the setae. The deepest colour is finally found in the eye, female genitalia, mouth-region, and on the back, where it forms a distinct transverse band on each segment.

A very characteristic feature of the females from a good proportion of localities, especially from muddy water, is the intense inky blue over the ventral parts of the body-segments and on the bases of the legs, with more diffused shades of blue in other parts; the edges of the body-segments are also lined with blue behind each of the

transverse brown bands already mentioned. The blending of the blue, brown, and white gives such specimens a particularly beautiful appearance.

Sars speaks of the males as "exhibiting in some places a faint bluish tinge." The writer has seen only very faint indications, and in comparatively few specimens, not nearly as deep as in Sars' figure. Indeed, in those cases where the female has the blue coloration, the colour constitutes a distinct secondary sex character by which the sexes may be readily distinguished, even with the naked eye; the males are brown, the females are brown with blue on the ventral parts. Other secondary sex differences are found in the smaller size of the male, the structure of the fifth pair of legs, the absence of projections on the last body-segment of the male, the number of joints in the abdomen, and the modification of the male right antenna. Females are about three times as numerous as males. Sars says that the maximum size of males and females respectively is 1.67 mm and 2.10 mm; the writer's measurements of 18 females and 8 males gave an average of 1.80 mm and 1.92 mm respectively, the maxima being 1.95 mm and 2.19 mm.

*Further General Observations.*—The animal is strongly attracted by light, though excited and repelled if the light is too intense. At night the eye, which is median and somewhat ventral, in a pellucid area between the antennae, appears as a conspicuously glistening red spot.

The heart is colourless; it is situated across the junction of the second and third body-segments, closely adjacent to the dorsal wall. The beat is rapid, generally 350-400 to the minute, though as many as 510 have been counted. The eye is in a state of continuous tremulation, and pulsations synchronous with the beat of the heart are noticeable at the base of each of the first antennae, and also backwards through the thorax, affecting the dorsal part of the intestine.

The intestine is yellowish. It performs regular lateral motions, which are not serpentine but extend simultaneously through the length of the animal. There is also a peristaltic contraction, giving a false appearance of constant ingestion. Between the intestine and the body-wall are a number of oil-globules, varying in number and size, but rarely exceeding twenty-four; they are found in young and old, except certain oviferous females. Although these globules might add to the food value of the animal for other organisms, it is difficult to imagine the rapid *Boeckella* being captured.

The spermatophore is pale yellowish, the sperms being contained in an inner sac which, by its variable size, suggests that the very abundant supply of sperms may be drawn upon from time to time. Occasionally it persists after a cluster of eggs has been laid, and extends from the side of the female genital opening to just beyond the ends of the caudal setae. The eggs, which though white in colour are so dense as to appear black under the microscope, are contained in a hyaline sac, and vary up to about twenty in number. The ovary is a double tube lying along the intestine on either side, the two parts approximating above it towards the head.

The projections on the last body-segment of the female are not long enough to protect the eggs, and the latter are not grasped by the fifth feet.

*The General Habits and the Movements of the Appendages.*—The general habits may be observed with a lens or dissecting microscope, and the finer details may be seen if the animal is mounted in water beneath a supported coverslip; if there is any difficulty in obtaining a lateral view the water should be drained off from some specimens in a watch-glass. As the animal commonly swims on its back in shallow water, views from all aspects may readily be obtained. Carmine is useful to show up the water-currents; chloroform is difficult to apply correctly, and unnecessary as the animal soon becomes sluggish in any case when mounted on a slide.

When a vessel of water containing *Boeckella* is agitated, the animals dart about with excessive rapidity. The flight is so sudden that little more than circumstantial evidence can be adduced to explain the means by which it is brought about; but there can be no doubt but that the anterior antennae are the organs of propulsion. Sars says that the movement is effected by a stroke of the swimming legs with a simultaneous bending forward of the abdomen, but this is the case only with another much less powerful type of progression. The bending forward of the abdomen could not drive the animal forwards, but in the opposite direction, this being the chief method of propulsion among certain higher Crustacea, notably the *Macrura*; and in the very rapid flights of *Boeckella* any extension of the legs would probably cause a frictional resistance greater than the propulsive action. The position of the legs is such that their use not only drives the animal forwards but tends to force the abdomen up and the head relatively down, and this tendency has to be corrected by the flexion of the abdomen as mentioned by Sars. But in the more powerful flights there is no place for such a rudder, which is also necessarily a brake. The fan-like arrangement of the caudal setae furnishes an admirable rudder for turning in a lateral or vertical direction during less rapid flights, and is constantly used for that purpose.

It may be noted that the anterior antennae are so placed that their stroke, unlike that of the legs, drives the animal straight forwards; that their large muscles are such as to give the necessary powerful stroke; that their great length gives them a leverage far exceeding that of any other appendages; that the terminal setae serve to "grip" the water, as it were, in such a way that the fulcrum is the water at their extreme tips; and that the normal attitude of the antennae, which are held almost straight out from the body (except that they bend forwards and outwards for a short distance near the base, and thence slightly backwards), is exactly that which is best suited for a sudden dart at short notice—there is no need for preliminary adjustment. Indeed, they resume their outstretched position so rapidly after a flight that the movement of the animal is somewhat abruptly checked by the consequent friction.

Less powerful darts have already been partly described. The legs are usually held straight forward in a bunched position, and a

simultaneous backward flexion, with the necessary counter-flexion of the abdomen, drives the animal forward for a short distance. Partly, no doubt, on account of the closeness of the legs to one another and the rich provision of setae, there is no continuous paddling such as occurs in the Callianassidae and other higher Crustacea, but by a repetition of the strokes the animal progresses by a series of jerks. The leverage is so small and the stroke so much less effectual than that of the antennae, that the legs actually move backwards through the water, so that they act as levers of the "first order," whereas the antennae are virtually of the "third order." The movement is sometimes and possibly always aided by a movement of the anterior antennae, but even these short darts appear so rapid under a lens, and the antennae regain their position so rapidly, that this is extremely difficult to verify. A slight movement of one antenna is sometimes used to change the direction of motion.

A backward kicking of the legs frequently occurs, without driving the animal appreciably forward; this is sometimes performed by the fifth pair only, or the first, or all together. In some cases at least the result is to free the legs or abdomen of small entangled particles of rubbish. The first pair of legs also sometimes poke food forwards towards the mouth. As will be explained below, the forward position of the legs has to do with the control of the food-carrying current: the fifth pair, however, are useless for such a function on account of their length and the deficiency of setae, and are not held forward in the bunch formed by the others, but are frequently in motion while the others are still. The outermost joints of the fifth pair are very flexible in a lateral direction, and frequently "comb" one another; the limbs may also bend inwards from the base, those of the female becoming momentarily interlocked by the curved hooks on the penultimate joints. The functions, if any, of these movements is not apparent, the special features of these limbs being no doubt concerned with copulation.

The rapid movements effected by the legs and antennae are much less constant than another type which may be described as a paddling movement. This was attributed by Sars to the posterior antennae, which are certainly the chief organs concerned; but the movement is really due to the concerted movement of various mouth-parts, and typically of all. The posterior antennae are remarkably long and muscular, and well provided with hairs and setae, and their consequent leverage and strength is sufficient to drive the animal slowly forwards; the antennae move with extraordinary rapidity, so that the forward movement is a continuous one. It is singularly persistent: the animal may be buffeted or almost deprived of water, but the paddling continues; so that the lack of response to teasing with a brush or other instrument is not a case of "shamming dead," as is commonly the case with *Cyclops*, but a placid refusal to be alarmed. In shallow water, several individuals may meet and paddle against one another; usually they do not trouble to change their course, and soon there may be a mass of paddling animals progressing not at all, or slowly in the direction of the majority. The arrival of a Cladocere makes no difference, the gentle and stately *Bocchella* being unperturbed even by such boisterous and clumsy interruptions.

As will be described more fully later on, the aim of the vibration of the mouth-parts is the creation of a water-current which carries food towards the mouth. The backwardly-directed parts of the mandibular and maxillary palps contribute by beating inwards, and the posterior foot-jaws beat forward in such a way as to deflect the current inwards and forwards again towards the mouth. The curvature of the setae in the direction of the stroke, and the curvature of the limbs themselves (see fig. 1) give power to the main stroke without counteracting its effect during the withdrawal of the appendage for the next stroke. The mouth-appendages move in unison at an exces-

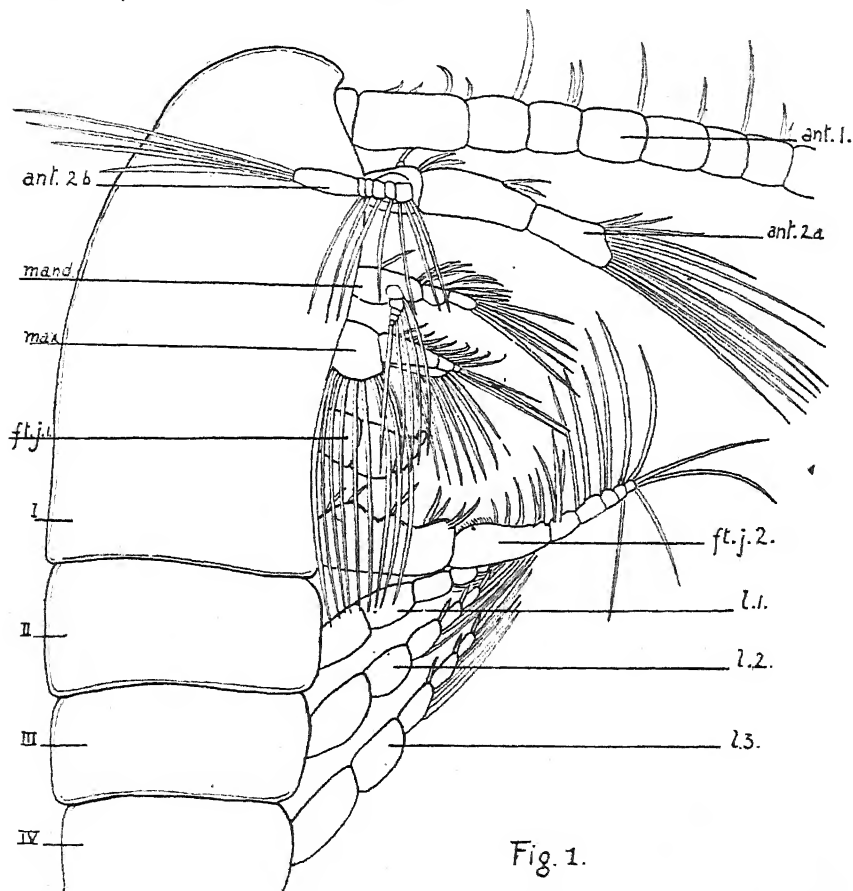


Fig. 1.

FIG. 1. *Boeckella triarticulata* G. M. Thomson. Lateral view of anterior part. X 100.

ant. 1.—basal part of anterior antenna.

ant. 2a. and ant. 2b. primary and secondary branches of posterior antennae, in their usual position.

mand.—mandible.

max.—maxilla.

ft. j. 1.—anterior foot-jaw. The setae are not shown.

ft. j. 2.—posterior foot-jaw, in forward position.

l. 1.—3.—legs.

I-IV.—body segments.

sively fast rate; although such concerted action might be expected when the controlling nervous system is so simple, it is essential in the case of the posterior antennae and posterior foot-jaws, for the arcs through which they move overlap. The rhythm is transmitted vigorously through all parts of the body, the caudal setae for example showing the vibration, sometimes even to an exaggerated extent. The rate varies somewhat, and also the amplitude of the movements, which in the case of a sluggish animal are reduced to a feeble quivering at the tips.

Commonly the mandibles and maxillae cease action, and at times the second pair of foot-jaws; it rarely happens that the latter are in motion while the posterior antennae are at rest. In the latter case the animal moves slowly backwards; the combined action of these opposing appendages sends the animal slowly forwards; while the posterior antennae alone send it more rapidly forward. All movement periodically stops, as if for a rest, and this also happens when a solid particle becomes entangled in the appendages. The animal is somewhat heavier than water, so that when not paddling it sinks slowly. On account of the anterior position of the posterior antennae, their action supports the head region rather than the abdomen, and (as in the case of a swimmer who paddles on his back with his hands only) the action causes the body to assume a semi-erect position, and the animal rises or falls in the water instead of travelling horizontally, except when in contact with the bottom. To travel forward, the legs or anterior antennae are generally used. The semi-erect position when the animal is hanging in the water may be inclined either forwards or backwards; at the bottom the animal may rest or paddle quite horizontally on its back, or may assume the normal position with the ventral surface undermost and stir up the mud at the bottom with the posterior antennae. To some small degree at least therefore *Boeckella* is a bottom-feeder, though not characteristically so.

The posterior antennae can take up either of two positions. In the one, both branches are directed ventrally and beat backwards, the secondary branch being in front of the primary; both branches then contribute to the food-carrying current. In the other position, which is more frequent, the secondary branch extends upwards over the back, and beats backwards in that position, as indicated in figs. 1 and 2. The structure of these appendages is interesting in view of their function; the secondary branch is unusually long, and is well provided with joints, so that it can readily curve round and pass upwards towards the dorsal surface; it is also provided not only with a tuft of very long terminal setae, like the primary branch, but also with a fringe of strong setae at the "elbow" where the curvature is most pronounced, so that its "grip" of the water is considerably increased. Though the movement of the appendage in this position contributes only indirectly, if at all, to the food-carrying current, its significance is interesting, for whereas a wholly ventral movement tends to raise one end of the animal and thus tilt it up unduly, as in the case of the swimming-legs also, the distribution of the action on both sides of the body by the two branches corrects this tendency.

The steady forward movement may be of value in bringing the animal constantly forward into fresh grazing-areas without the loss of the advantage of the current already set up, as is the case after a rapid dart. The movement is the outcome of numerous factors—the resultant action of the mouth-parts, which partly oppose one another, and the frictional resistance of the anterior antennae, abdominal setae, and body generally. This frictional resistance must be considerable in the case of the anterior antennae especially, either when swimming forward or rising or sinking; this is well illustrated in the case of the male, for the expansion of the modified right antenna increases the friction to such an extent that the animal is deflected to the right. A specimen in which one antenna was accidentally amputated travelled round in narrow circles, the centre being the tip of the remaining antenna. Sars remarks that the anterior antennae serve “apparently as a sort of balancing apparatus.” A stroke of the legs, a lateral or ventral flection of

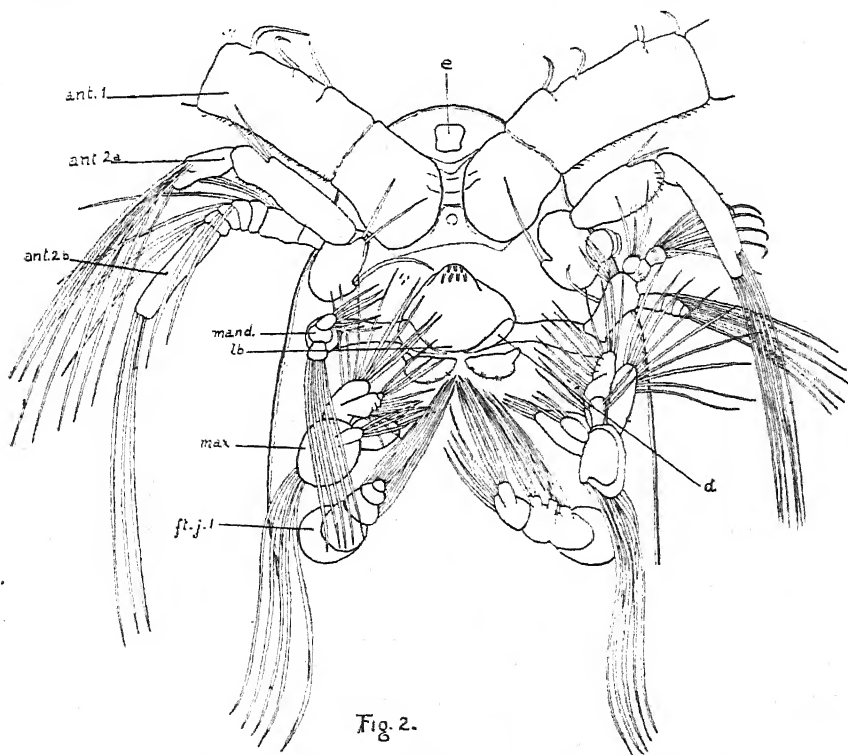


Fig. 2.

FIG. 2. *Boeckella triarticulata* G. M. Thomson. Ventral view of head region. Lettering as in Fig. 1, also: *e*.—eye. *lb.*—labrum. *d.*—cutting part of mandible. X 100.

The anterior antennae are represented as if cut off short. The left posterior antennae (right side of figure) shows the primary branch folded somewhat backwards, and the secondary branch bent round to the back; the right shows both branches. The posterior foot-jaws, which overlie the others, are not shown. The remaining mouth-parts are in their usual position on the left side of the figure, but show the structure more clearly on the right.

the abdomen, or a slight flick of one antenna, may be used to correct the direction of motion.

The process of food-capture remains to be described. Seen from the ventral surface, the mouth-parts are arranged in an almost continuous circle round the mouth (fig. 2), the only break being anterior to the mouth. The posterior antennae (or usually their primary branches) extend ventrally on either side from a forward position; the mandibles and maxillae arise at the side of the mouth, with branches directed backwards as well as towards the mouth; the anterior foot-jaws point inwards and forwards towards the mouth, and the posterior pair work above them, while in the median line is the bunch of swimming-legs. Part of the water-current which is swept backwards by the posterior antennae is caught by the posterior foot-jaws and deflected towards the body; it is met by the legs, and swirled forwards to the mouth. The length of the legs and their setae is sufficient to bring the tips of the setae to about the same level when held forward in the usual manner. The current is further prevented from passing backwards round the bases of the legs by the anterior foot-jaws and the maxillary palps, and though some does escape in that way, the organs mentioned remove any solid particles and retain them. The backwardly-directed branch of the maxillary palp is a broad disc-shaped expansion, from the margin of which arises a palisade of remarkably long and doubly-curved setae, which pass backwards beyond the foot-jaws. Seen laterally, these setae pass at right angles across the series on the posterior foot-jaws, and form an effective barrier to the escape of solid particles. When the maxillae come to rest, the water passes out somewhat freely through the grating, but not the particles; their effectiveness is illustrated when carmine is added to the water, for they speedily become clogged. The mandible-palps are longer and two-branched, with long and numerous setae. One branch guards the space between the mandibles and maxillae, the other extends towards the mouth, and a sparse fringe of setae stretches forward towards the posterior antennae.

The several functions of the mandibular and maxillary palps—the active beating in order to drive on the water-current, the poking of food to the mouth, and the retention of particles from the escaping water—are difficult to distinguish, especially as they are somewhat interfered with under the microscope. Those setae which point to the mouth, and especially those of the posterior foot-jaws, which extend to the opening of the funnel, are capable of directing the movement of solid particles to the mouth, whatever the course of the water or the action of the limbs themselves. The dental areas of the mandibles are held vertically between the labrum and the corresponding parts of the maxillae; the latter are triangular structures held horizontally, forming the funnel-like entrance to the mouth proper. The inner parts of the mandibles and maxillae do not move in unison with the palps and other mouth-parts, but more slowly, though they are capable of vigorous action when necessary.

Although there is a certain unavoidable waste of energy in that much of the water-current swirls past beyond reach, the mouth-parts are admirably constructed for the functions they fulfil. The legs

are well provided with ciliated setae, probably beyond their requirements as propulsive organs, but effective in causing the necessary eddy in the water-current. The posterior foot-jaws, whose continuous action is essential for food-capture, are particularly strong, and are long enough to reach well out into the water-current; they are bent forward, and throughout their length have a row of cilia of which the outermost are directed outwardly into the current, while the more basal ones point downwards and forwards in the direction in which the current is to travel. The anterior foot-jaws, which are passive except for their poking-action, are smaller, but have numerous setae which extend inwards and forwards right into the funnel-aperture. The differentiation of the palps of the maxillae and mandibles into two parts—inwardly-directed and lateral respectively—has already been noted. The labrum rises like a wall at the inner end of the funnel, and beyond it is a median projection carrying a few short spines curved towards the mouth in such a way as to catch particles which may sweep across the labrum. On the basal joint of the posterior antennae is a long curved spine which may perhaps serve to force such particles back again within reach of the other mouth-parts.

Although there is always a danger of misconception in such interpretations as have been attempted in this paper, the investigation has shown, to the writer at least, that the appendages of such creatures as *Boeckella* have a further interest beyond their use in distinguishing new species.

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While this article was in the press, I received, through the kindness of Dr. V. Brehm, of Eger, a copy of his account of the Copepoda (issued May 15th, 1927) in Vol. 3 of the "Handbuch der Zoologie," edited by Dr. W. Kükenthal. As if to anticipate my remark above, a brief statement of the feeding mechanism of *Diaptomus* sp. is therein given (pp. 467—8), and the illustrations (figs. 429 and 430) are very similar to those in the present paper. Dr. Brehm acknowledges as the source of his figures and information on this subject a paper by O. Storch and O. Pfisterer ("Der Fangapparat von *Diaptomus*," Zeitschr. f. wissensch. Biol., Abt. C, Bd. 3, 1925), and though I have not seen the original paper a few comparisons may be made.

For the most part, the account is similar to that given above in the case of *Boeckella*, but there are some differences, such as the rate of vibration of the mouth-parts. In *Diaptomus* the rate is "more than 300 per minute," while in *Boeckella* it is more than twice as great, and perhaps as much as 1,000 per minute.

The most striking point, however, is that although the footjaws are figured, no mention of them occurs in the text. If a forward beating movement occurred, as obvious and important as that in *Boeckella*, it could hardly be overlooked; the setae are very much shorter, and quite a different explanation is given for the forward diversion towards the mouth of the inner part of the backward water-current. In *Boeckella* I have attributed this to the bunch of swim-

ming-legs and especially to the stroke of the posterior foot-jaws, but in the case of *Diaptomus* the only cause mentioned is the suction of the backward current as it streams along the sides past the mouth-parts; this suction withdraws water from the median region, and the replacement of this causes the steady forward flow towards the mouth. This forward current, which is distinguished from the general "Lokomotionsstrom" as the "Speisestrom" or food-current, passes forward within the median passage defined by the anterior footjaws, is drawn through the filtering setae of the latter, and is sucked backwards again as an "Aspirationsstrom" or exhalant current, through the "exhalant gap" between the maxillae and the anterior footjaws.

In *Boeckella* such a clearly-defined exhalant current was not observed, and this difference is reflected in the different arrangement of the mouth-parts. In *Diaptomus*, for example, the labrum is figured in lateral view as extending outwards as far as the end-segments of the mandibles and maxillae, whereas in *Boeckella* it is not even visible from that aspect. Such an enlargement would not only arrest the forward current at the level of the mouth, but also, if the exhalant current depends on suction, would be necessary to prevent a backward flow of unstrained water across the mouth. If there is a genuine suction in the case of *Diaptomus*, it must undoubtedly be present in *Boeckella* also; but in the latter the current is not dependent upon suction, but is forced forward by the stroke of the posterior footjaws. For this reason, no such expansion of the labrum is necessary to shield the mouth-region from the general backward current, and likewise the forward current is able to pass outwards at any point, even anterior to the mouth.

In the account and figures of *Diaptomus* it is insisted that while the posterior antennae, mandibles, and maxillae are situated forward in a group, there is a wide interval between them and the anterior footjaws, forming an exhalant gap. This is certainly not the case in *Boeckella* (see fig. 2), nor is there a clearly-defined channel leading to the small interstice that does exist. In *Diaptomus* the long backwardly-directed setae of the maxillae are much more strongly curved; they are not spoken of as assisting the anterior footjaws in straining the food from the current, but merely as aiding in the creation of the general backward current. To account fully for these differences, and especially to elucidate the mystery of the posterior footjaws in *Diaptomus*, the full text of Storch's paper would be necessary.

## Notes on New Zealand Fishes.

By W. J. PHILLIPPS.

Read before the Wellington Philosophical Society, August 25th, 1926;  
received by Editor February 2nd, 1927; issued separately  
10th August, 1927.]

(Plates 3-8.)

### FAMILY MACROURIDAE.

Genus COELORHYNCHUS Giorna, 1803.

*Coelorhynchus oliverianus* n. sp. (Fig. 1.)

D. 1 + 11 + (87 approx.); A. 90 (approx.);  
V. 7; P. 12; L. lat. 132.

HEAD is a little under 5; depth of body at dorsal origin 7.14; depth at posterior margin of orbital cavity 7.69; and depth at 35th anal ray 25 in total length. Intra-dorsal space equal to height of orbital cavity which is 3.21 in head.

Snout short and blunt; its length to orbital cavity being 1.71 and inter-orbital space 1.33 in lateral diameter of same. Mouth inferior, the distance from its front edge to snout being 4.69 in head; maxilla extends to vert. under posterior half of eye. Sub-orbital ridge prominent; rostro-infraorbital ridge well marked and slightly sinuous.

Band of villiform teeth in both jaws. Scales large, there being but 3.5 to 4 in series between lateral lines and second dorsal. Lateral line sloping downwards above pectoral, posteriorly running in middle line, and having 48 scales to 39th anal ray.

Pectoral origin in advance of dorsal which rises above anal. Minute 1st dorsal spine is 25.33 in second which is slightly less than length of pectoral. Second dorsal composed of small spiny rays with delicate membranous connection; 35th anal ray is typical of others and is approximately 3 in head. Pectoral reaches to 3rd ray of second dorsal almost as far as 1st dorsal when laid back; 1st ventral ray very long reaching to 2nd ray of 2nd dorsal.

Two examples 300 mm. in total length were secured by Island Bay fishermen. These were given to Mr. W. R. B. Oliver, who added them to the Museum collection. The eyes are larger in one example than they are in the other, the one with the smaller eyes having been described. The two fish have been designated syntypes.

*Discussion.*—*Coelorhynchus australis* Richardson and *Coelorhynchus aspercephalus* Waite were recorded by Waite (*Rec. Cant. Mus.*, 1, pp. 176-180, pls. 29, figs. 1 and 2). These species are widely different from the one under consideration in which the shape of the body appears to agree more nearly with *Coelorhynchus anatirostris* Jordan and Gilbert from Japan. The attenuate tail of *Coelorhynchus oliverianus* is typical of members of the genus *Hyemnocephalus* Giglioli known from deep waters of Japan.

In his record of deep-sea fishes of Challenger (vol. 22, pl. 29, fig. a. 1887), Guenther recorded *Coelorhynchus parallelus* from the Kermadecs. The type of this species was, however, taken in Japan, so Jordan and Gilbert (*Bull. U.S. Fish Comm.*, vol. 22, p. 619, 1902) have suggested the new name, *Coelorhynchus kermadecus*.

The following key will serve to separate the four species already mentioned:—

- A. Distance between 1st and 2nd dorsals approximately equal to base of 1st dorsal.
- B. Snout longer than eye. . . . *australis*.
- BB. Snout shorter than eye. . . . *oliverianus*.
- AA. Distance between 1st and 2nd dorsals distinctly longer than base of 1st dorsal. . . . *kermadecus*.
- AAA. Distance between 1st and 2nd dorsals distinctly shorter than base of 1st dorsal. . . . *aspercephalus*.

## FAMILY SERRANIDAE.

### Genus POLYPRION Cuvier, 1829.

Two species of *Polyprion* have been identified in our waters. These are *oxygeneios* and *americanus*. The first is peculiar to New Zealand, and the second is widely distributed. On attempting to formulate a table for the ready identification of the indigenous species of *Polyprion*, I found that the species hitherto regarded as identical with *americanus* differed from the northern form in one or more important respects. In particular the relations of the pectoral fin, 6th dorsal spine, anal fin and head showed the New Zealand bass to be in a different class to the stone bass of Europe. After examination of numerous hapuku and bass in our local markets my conclusion is that we have in the indigenous bass a new species. This has already been well described by Waite, (*Trans. N.Z. Inst.*, 45, p. 215, pl. 5, 1913), who regarded it as identical with *Polyprion americanus*. I suggest that Waite's example be regarded as the type of a new species to be known as *moeone*, the present name in common use among the Maori.

*Discussion.*—Boulenger (*Cat. Fish. Brit. Mus.*, vol. 1, p. 150, 1895), has given a good description of *Polyprion americanus*. The scales in the lateral line are here 82-90, while in *Polyprion moeone* this number is generally 96. Both Boulenger and Goode and Bean (*Ocean Ichth.*, p. 238, fig. 238, 1895) give the pectoral as shorter than the ventral in *americanus*. Waite (*loc. cit.*) gives the ventral as short, one-third the length of the head. The numbers of fin rays in *americanus* and *moeone* appear to be almost identical so that Waite's conclusion that the New Zealand and European bass were identical is not unnatural. In *moeone* the ventral is smaller than the pectoral in relations varying from 1.2 to 1.35, and in *oxygeneios* the pectoral is smaller than the ventral in relations varying from 1.1 to 1.25. Odd examples of *oxygeneios* have been examined in which the lengths of pectorals and ventrals were approximately equal. These were fully adult specimens.

The following is a key to the three species of *Polyprion* already mentioned:—

- A. First dorsal fin high, the 6th dorsal spine being approximately equal to the length of pectoral.
  - b. Pectoral fin shorter than or equal to ventral and less than half the length of head . . . *oxygeneois*.
- AA. First dorsal fin low, the 6th dorsal spine being distinctly less than length of pectoral.
  - bb. Pectoral fin shorter than ventral and half length of head. . . . *americanus*.
  - c. Pectoral fin longer than ventral and less than half the length of head . . . *moeone*.

## FAMILY SCORPAENIDAE.

Genus SEBASTODES Gill, 1861.

*Sebastes maccullochi* n. sp. (Fig. 2.).

- D. 11 + 1 + 13;
- C. 5 + 12 + 5;
- A. 3 + 5; V. 1 + 5;
- P. 11 + 7.

Head is 3.31 in total length or 2 in distance snout to anal. Body compressed and head a little flattened; lower jaw slightly the longer. Maxillary reaches back to posterior margin of eye diameter of which is 4.25 and interorbital space 6.44 in head. Opercular edge clear. Depth at operculum is 4.08 in total length.

Spines: Towards ventral surface posterior to eye are 4 small backwardly directed spines, the topmost being largest. Posterior to the eye and well in from the opercular edge are three more small spines while a further series is on top of head. This latter consists of seven pairs of small spines running above eyes and turning outwards towards the commencement of lateral line. In relation to eye one pair is in front of the anterior edge, three pairs above, one pair above posterior margin, and two behind.

Fins: Dorsal commences above base of the most posteriorly placed spine. Pectoral has a wide scaly base, and is approximately equal to the ventral which commences slightly further back. Caudal is slightly emarginate.

Lateral line commences at upper opercular angle distinctly in advance of dorsal. As far as can be ascertained there are some 36 scales to a point below last dorsal spine and about 60 in lateral line.

*Discussion:* I place this species provisionally in the genus *Sebastes* Gill; but it differs from described examples in that genus in the size of eye and the fewer number of spines in the first dorsal. The arrangement of the spines and general appearance is similar to that of *Sebastes schlegelli* (Hilgendorf) figured by Jordan, Tanaka, and Snyder, (*Cat. Fish. Japan., Journ. Coll. Sci., Tokyo*, p. 233, fig. 167, 1913).

Type: The type was taken from the stomach of a red cod *Phycisculus bachus* secured in Cook Strait in April. The specific name *macculochi* is given in recognition of help which I have received from the late A. R. McCulloch, of Sydney Museum.

## FAMILY CARANGIDAE.

### Genus *SERIOLA* Cuvier.

#### *Seriola grandis* Castlenau. King-fish.

*Seriola grandis* Castelnau, *Proc. Zool. Soc. Vict.*, 1, p. 114, 1872; *ibid.*, McCulloch, *Endeavour. Res. Aust.*, 3, p. 121, pl. 35, fig. 1, 1915.

*Seriola lalandii* Cuv. and Val.: Hutton, *Cat. N.Z. Fish.*, p. 17, 1872; *ibid.*, Sherrin, *Hand-Book. Fish. N.Z.*, p. 39; *ibid.*, Sandager, *Trans. N.Z. Inst.*, 20, p. 129, 1888; *ibid.*, Hutton, *Trans. N.Z. Inst.*, 22, p. 278, 1890; and *Index Faunae, N.Z.*, p. 44, 1904.

*Seriola lalandi* Cuv. and Val.: Waite, *Rec. Cant. Mus.*, 1, p. 23, 1907; *ibid.*, Phillipps, *N.Z. Journ. Sci. and Tech.*, 4, p. 117, No. 30, 1921, and 5, p. 93, No. 30, 1922.

Jordan and Evermann (*Bull. U.S. Nat. Mus.*, 47, p. 901, pl. 140, 1896) separate the four species of *Seriola* in North America on relative numbers of dorsal rays (36 to 38 and 30 to 40), the size of the maxilla and relative depths. The species *lalandi*, has D. 1 + 34 and A. 1 + 27; head  $3\frac{1}{2}$  to  $4\frac{1}{4}$ ; depth  $3\frac{1}{2}$  to  $3\frac{3}{4}$ ; and maxilla reaching to middle of pupil, while "*dumerili*" has a deeper body (3 in length) and grows to a smaller size, but is otherwise closely related to *lalandi*.

McCulloch (1915, *loc. cit.*) has described *Seriola grandis* Castelnau. This species has depth 4.6 in the length from the premaxillary symphysis to the end of the middle caudal lobes, and head 3.9 to 4.2 in the same. McCulloch states: This species has been confused with the Atlantic *S. lalandi* Cuv. and Val.; but it differs from Jordan and Evermann's\* figure of that species in being more slender and in having the proper profile of the head less convex. It is possibly identical with *S. aureorittata* Schlegel as suggested by McCoy, but the illustrations of that species indicate that the Japanese fish is somewhat deeper in form than the Australian one.

The accompanying figure (Fig. 3) is taken from a drawing by Clarke hitherto unlabelled. This is undoubtedly a representation of the New Zealand species of *Seriola*. The tail is distinctly yellow and the upper surface deep blue. The iris of the eye is golden and the undersurface white. The following descriptive material is taken from the drawing:—

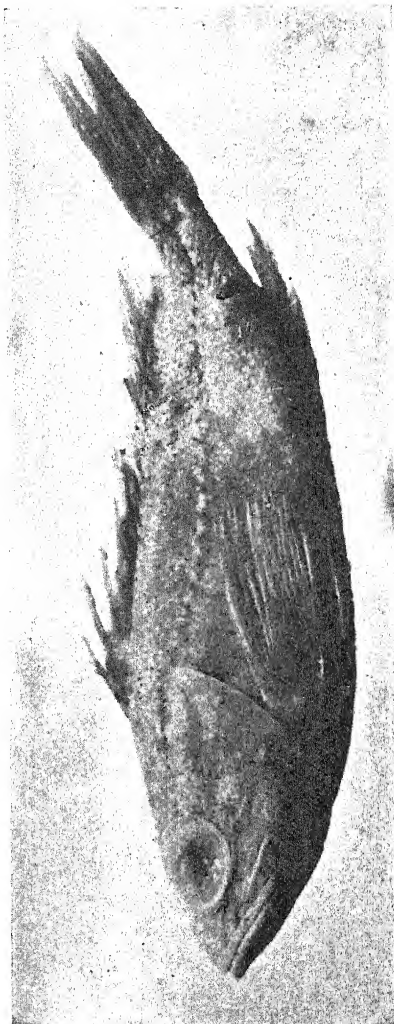
D. 6 + 1 + 33; C. 18; A. 3 + 21; V. 1 + 5; P. 22. The head is 4.24 in total length or 3.84 in length to caudal constriction. Maxilla reaches to beneath anterior half of eye; but not as far back as centre of pupil. Depth at operculum is 5.15 and depth at 2nd dorsal 4.79 in total length.

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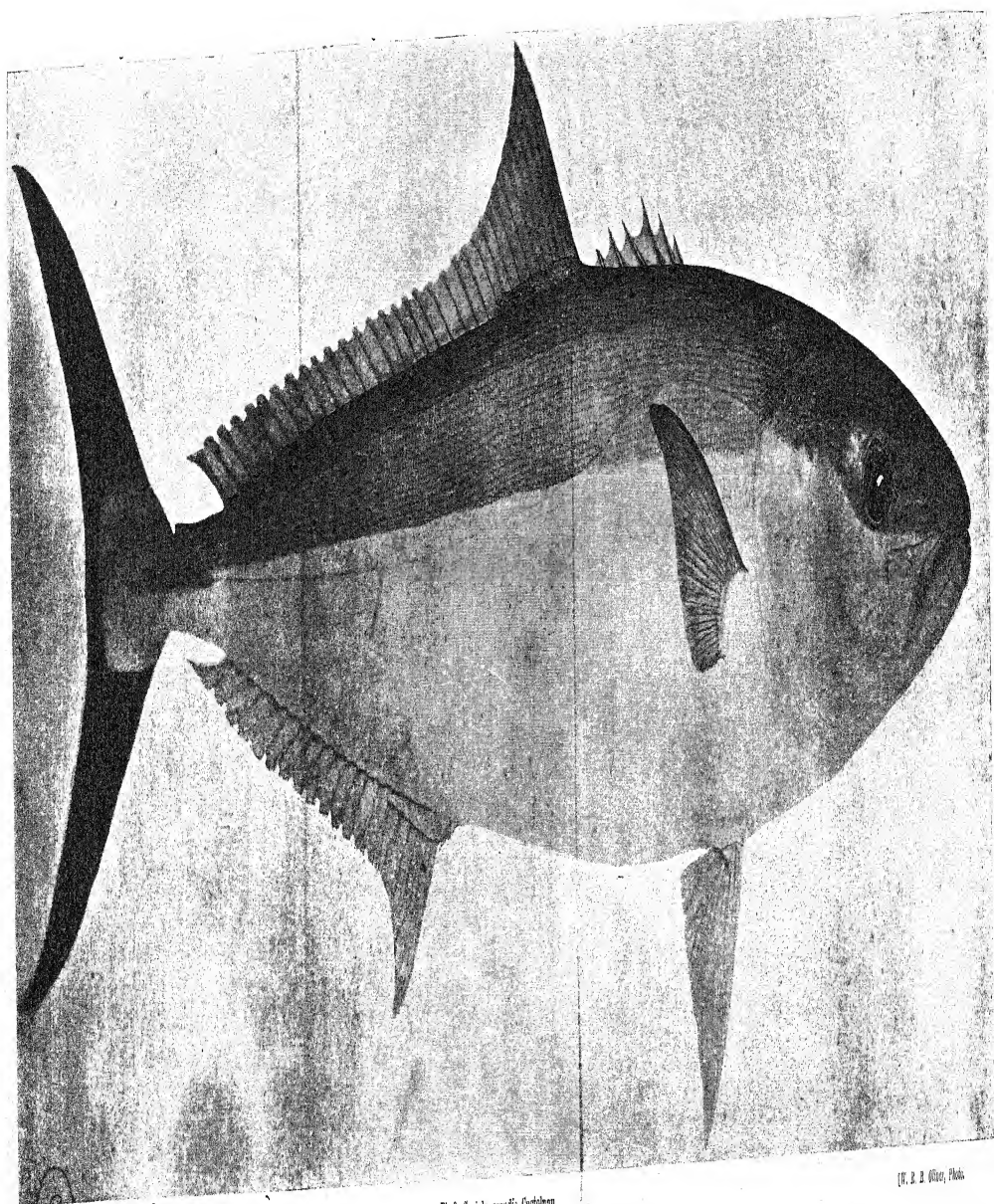
\*Jordan and Evermann. *Bull. U.S. Nat. Mus.*, 47, p. 901, pl. 140, 1896.



Pl. 1. *Coelorhynchus oliverianus*, n. sp. [W. R. B. Oliver, Photo.]



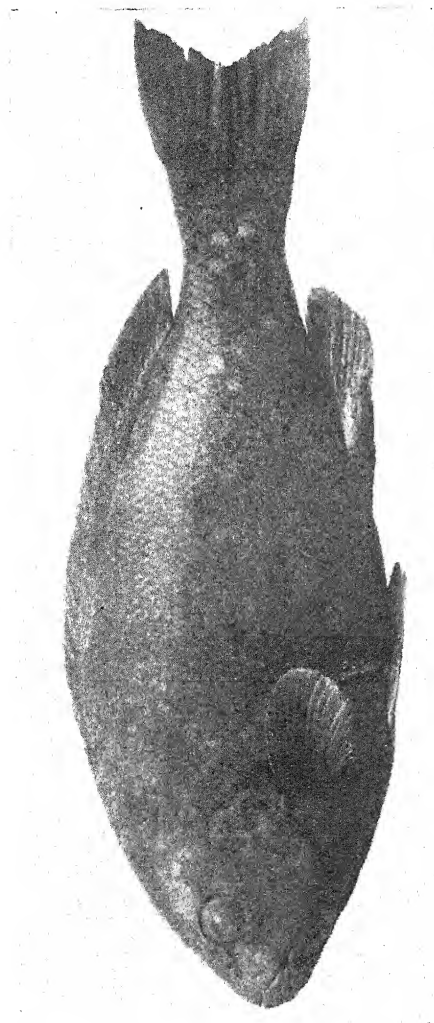
Pl. 2. *Sebastodes maccullochi*, n. sp. [W. R. B. Oliver, Photo.]



Pt. 3. *Seriola grandis* Castelnau.

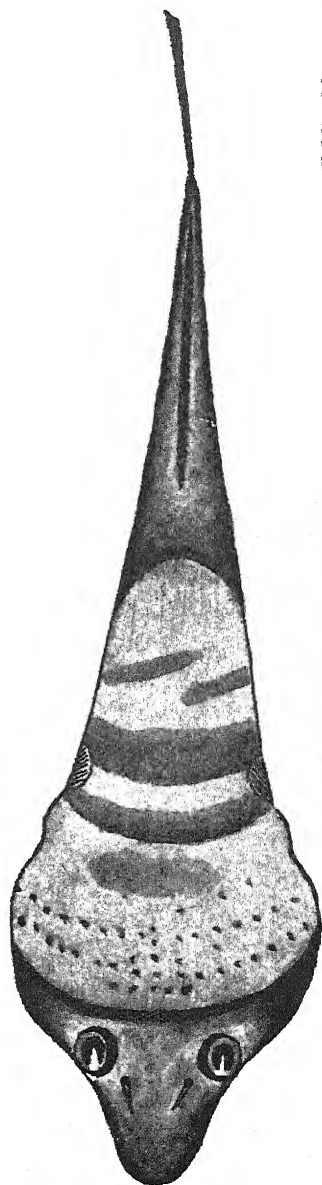
(H. & B. Oliver, Photo)





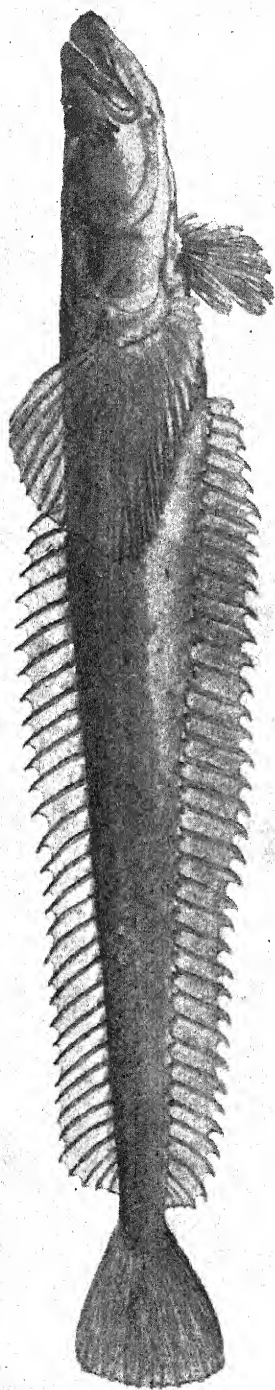
Pl. 4. *Sparus hamiltoni* n. sp.

[W. R. B. Oliver, Photo.]



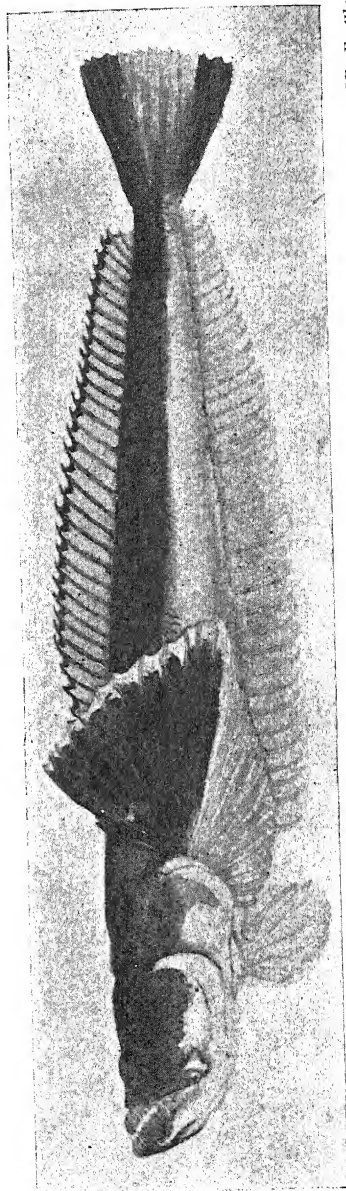
Pl. 5. *Trachelocheismus melobesia* n. sp.

[W. J. P., del.]



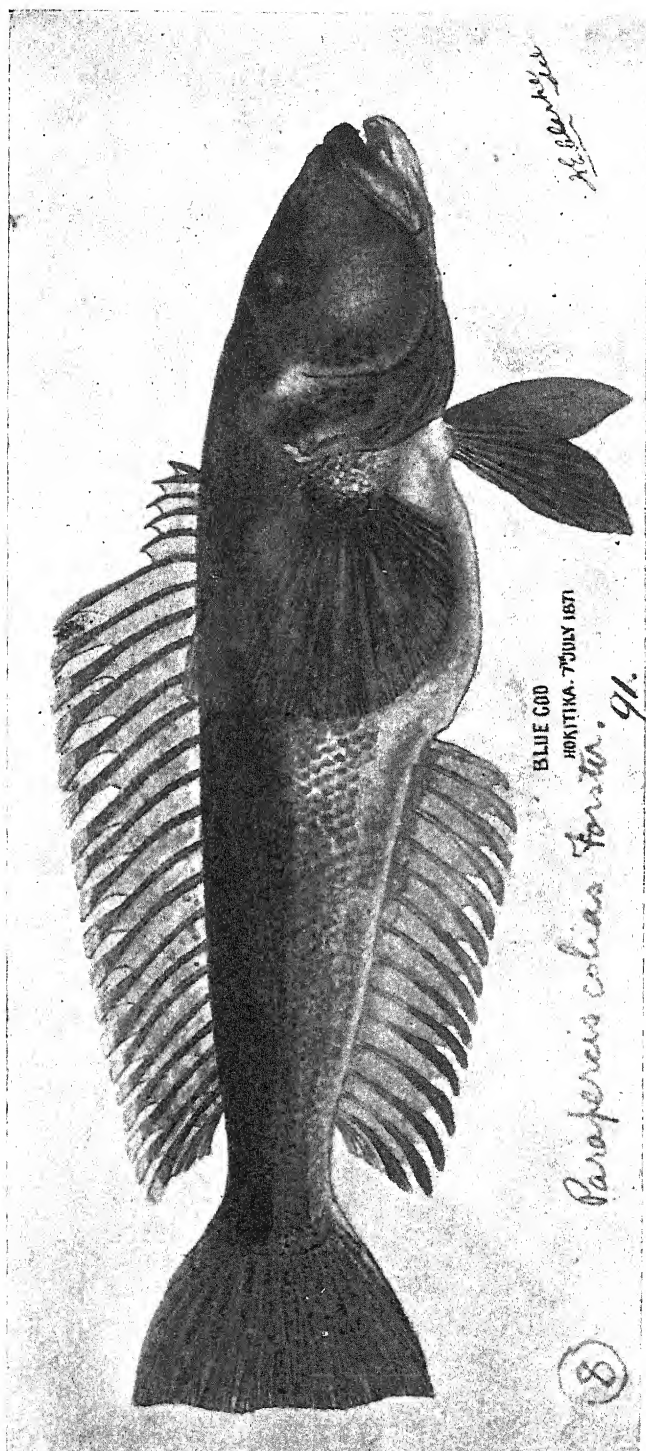
[F. E. Clarke, del.]

Pl. 6. *Crapatalus notae-zelandiae* Guenther.

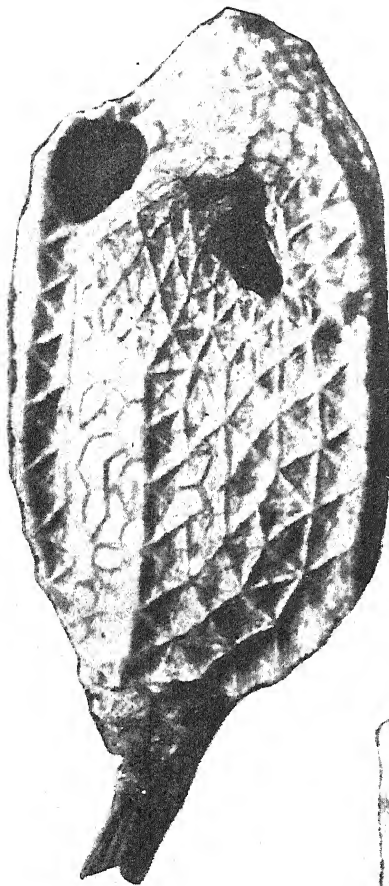


[F. E. Clarke, del.]

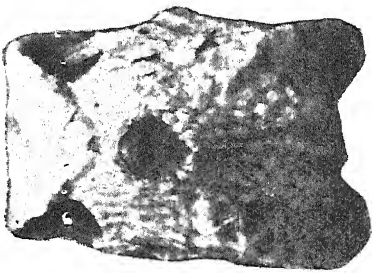
Pl. 7. *Leptoscopus macropygus* (Richardson).



Pl. 8. *Paraperca colias* (Forster).



Pl. 9. *Ostracion hexagonus* n. sp. H. Hamilton, photo.  
(Side View).



(Front view.)

In the example figured by McCulloch (1915, *loc. cit.*) the head is 4.54 in total length or 3.66 in length to caudal constriction which is not so deeply marked as in above. The maxilla reaches to under the eye in McCulloch's example, and the depth at operculum is 5.81, and depth at 2nd dorsal 5.17 in total length.

Roughley (*Fishes of Australia*, p. 98, pl. 30, 1916) figured this species with depth at operculum 5 and depth at 2nd dorsal 4.86 in length. Head is here 4.37 in total length. Describing the species the author gives the height as  $4\frac{3}{4}$  to  $5\frac{1}{4}$  in the total length. McCoy (*Prod. Zool. Vict.*, dec. 18, pl. 172, 1889) has described the Australian species under the name of *Seriola lalandi* (Cuv. and Val.). He gives greatest depth at origin of second dorsal, this being about  $4\frac{1}{2}$  in total length. Measuring from his figure I get head 4.71 and depth at operculum 5.21 in total length.

Among the New Zealand fishes in the Dominion Museum is a stuffed specimen labelled *Seriola lalandi*. It has head 4.57; depth at operculum 4.8 and depth at 2nd dorsal 4.57 (approx.) in total length. A certain amount of shrinkage has taken place in this example; and allowance has been made for this. A Bay of Islands king-fish had head 4.66; depth at operculum 5.25 and depth at 2nd dorsal 4.3 in total length. Napier examples had depth at operculum 5.43 and depth at anus 5.77 in total length.

To summarize Australian examples mentioned—head is 4.37 to 4.71, the depth at operculum 5 to 5.81, and the depth at 2nd dorsal  $4\frac{1}{2}$  to 5.17 in total length. New Zealand specimens have head 4.24 to 4.66; the depth at operculum 4.8 to 5.43; the depth at 2nd dorsal 4.3 to 4.79. A comparison of the fin formulas of New Zealand and Australian examples shows slight variations in practically all examples. I can arrive at no other conclusion than that these New Zealand and Australian species of *Seriola* are identical; but am as yet doubtful of the validity of the characters separating *lalandi* and *grandis*.

It would appear that in *lalandi* of the Mediterranean and Atlantic the depth of the body is  $3\frac{1}{2}$  to  $3\frac{3}{4}$  in length and the maxillary reaches to middle of pupil. In *grandis* of Australia and New Zealand the depth is over 4 and the maxillary reaches to under anterior  $\frac{1}{3}$  of eye. The New Zealand kingfish thus becomes *Seriola grandis* Castelnau.

This king-fish is caught in large numbers on a reef some miles off the shore from Napier. The launches leave Port Ahuriri some hours before daybreak, and on arrival at the reefs trolling operations are commenced. These continue until daylight when the fish suddenly fail to take the silvered hook. Through the courtesy of Mr. R. Boyd, Westshore, Napier, I was enabled to observe this interesting fishery. In the hour and a half before the sun rose some dozen fish measuring from 3 to 5 feet were taken by one launch; six launches following each other in circles around and over the reefs. When the first rays of the morning sun shone in the east, the king-fish ceased to bite, all the launches returning home. I am informed that the North Auckland king-fish may always be taken in the daytime; but have seen only one thus secured. The species is most common in the warmer waters of North Auckland and the Bay of Plenty, and less plentiful

in Cook Strait, being rare as far south as Otago. I have recorded it in Wellington markets during January, February and March. It is fairly common in Auckland except from June to October, when it is rare. Sandager (*loc. cit.*) writes: "Very few are caught during October, November and December. It probably spawns about this time. The largest I have caught measured 4ft.  $7\frac{1}{2}$  inches in total length."

### FAMILY SPARIDAE.

*Genus* SPARUS Linn., 1758.

*Sparus hamiltoni* n. sp. (Fig. 4).

D. 14 + 14; C. 16; A. 3 + 11; V. 1 + 15; P. 18. L. lat 69.

Head is 5; depth at dorsal origin 3.21; depth at anal origin 3.07 in total length. Eye is 4.55 and snout 3.12 in head. Mouth small, maxilla not reaching back as far as anterior margin of orbit; jaws sub-equal, and upper profile rounded. Body compressed.

Dorsal originates at a point behind opercular edge 4.55 in total length, spines increasing to 6th which is three times height of 1st, and is contained 1.48 in 6th soft dorsal ray. Dorsal reaches further back than anal which commences beneath posterior dorsal spines. Caudal deeply emarginate. Pectoral reaches to over half the length of ventral, which is 1.58 in distance from its origin to anal.

Teeth are tri-dentate in outer series in both jaws with smaller similar teeth behind. There are 8-9 scales between lateral line and second dorsal. Total length 250 mm.

This species is common in Hauraki Gulf. Numerous young were collected in rock pools at Poor Knights Islands by Messrs. W. R. B. Oliver and H. Hamilton. In Australia the genus *Sparus* is represented by the two species *australis* and *sarba*. *S. australis* is the famous black bream which grows to 22 inches and weighs  $7\frac{1}{2}$  lbs and of which Stead (*Edible Fishes of N.S.W.*, p. 77, pl. 46, 1908), says:—"A weight of about 1,350,000 pounds is at present sold annually through the fish markets of New South Wales." The tarwhine, *Sparus sarba*, more nearly resembles the species above described, but differs in several important respects, some of which are the distinctly longer pectoral, shorter ventral and smaller number of rays in the second dorsal.

### FAMILY GOBIESOCIDAE.

*Genus* TRACHELOCHISMUS Brisson, 1846.

*Trachelochismus melobesia*, n. sp. (Fig. 5).

D. 10; C. (about 12); A. 8; V. 3; P. 10.

Teeth in both jaws, those in lower being much larger than in upper; 3 gills with half a gill in front. Lips thick; angle of mouth in front of anterior margin of eye diameter of which is equal to inter-orbital space and greater than half vert. distance eye to

snout. Eyelids present. Head wide and flattened dorso-ventrally, being 3.11 in total length or 2.64 in length to base of caudal. The greatest width of head 5 mm. from snout is 1.2 in head or 3.73 in total length.

Body flattened dorso-ventrally anteriorly and compressed posteriorly; its width tapering from head to caudal peduncle. Sucking apparatus on under surface consisting of circular disc and fused ventrals in front of it. Sucking disc is 7 in total length or more than half distance to snout. Ventral rays fused, three being visible under microscope. Anus nearer tip of caudal than snout; dorsal origin in advance of anal and 1.67 in total length. Pectorals large and rounded.

Colour: General ground colour is rose-pink tending to scarlet on the tail and fins. The undersurface is pink with yellowish tinges on the adhesive apparatus. A deep reddish-purple patch covers most of the dorsal surface. This patch extends from behind the eyes to the dorsal origin and has running across it anteriorly a dotted pattern, behind which are two fairly wide cross bars of reddish brown.

Occurrence: Numerous specimens the largest of which do not exceed 30 mm. were secured by Mr. W. R. B. Oliver in rock pools at Makara near Wellington. The species, though so long undescribed, is apparently quite common on the underside of rocks in beach pools on the westerly coasts of Wellington. The specific name has particular reference to the rose-coloured patch by which the species may readily be distinguished. The above description was taken from an example 28 mm. long.

Discussion: The "Synopsis of the Genera of the Family "Gobioidae" as supplied by Guenther (*Cat. Fish. B.M.*, vol. 3, p. 490, 1861), would make the present species to be most probably a member of the genus *Trachelochismus*; but its distinctive large dorsal and anal and smaller number of ventral rays may later compel its separation from this typically southern genus.

## FAMILY LEPTOSCOPIDAE.

Two species belonging to separate genera are found in New Zealand. These are:—*Leptoscopus macropygus* (Richardson) and *Crapatalus novae-zelandiae* Guenther. For the separation of the genera, McCulloch, (*Check-list, Fish, N.S.W.*, p. 102, 1921), supplies the following key:—

A. Scales larger, about five between lateral line and back. . . . *Crapatalus*.

AA. Scales smaller, more than five between lateral line and back. . . . *Leptoscopus*.

*Crapatalus* is the more elongate, the head (including lower jaw) being over  $4\frac{1}{2}$  in total length. In *Leptoscopus* this measurement is under 4. Both have Br. 6; V. 1 + 5; and C. 14, and are closely related genera. It is of interest to note that *C. novae-zelandiae* and

*L. macropygus* have each been taken in fresh water. This is probably a periodic migration.

## FAMILY LEPTOSCOPIDAE.

Genus CRAPATALUS Guenther, 1861.

*Crapatalus novae-zelandiae* Guenther. Sand-fish (Fig. 6).

*Crapatalus novae-zelandiae* Guenther, *A.M.N.H.*, 7 ser. 3, p. 87, 1861; *ibid.*, Hutton, *Trans. N.Z. Inst.*, 8, p. 212, 1876; *ibid.*, Gill, *Mem. Nat. Acad. Sci.*, 6, p. 118, 1893; *ibid.*, Waite, *Rec. Cant. Mus.*, 1, p. 239, 1911.

*Leptoscopus angusticeps* Hector, *Trans. N.Z. Inst.*, 6, p. 106, pl. 19, 1874.

*Leptoscopus robsoni* Hector, *Trans. N.Z. Inst.*, 7, p. 248, 1875.

*Leptoscopus canis*, Arthur, *Trans. N.Z. Inst.*, 17, p. 165, pl. 14, 1885.

This species is well described by Waite (*Rec. Cant. Mus.*, 1, p. 239, 1911). I found the sand-fish to be not uncommon at Greymouth and Hokitika, and am now informed that it is a good edible species. Clarke has attached to his figure of the species the following:—D. 33; P. 1+20; V. 1+5; A. 39; C. 14; B. 6. Considerable variation may be evident in individual examples; but as a general rule head is 4.8 in total length, dorsal rays do not exceed 35 and ventral does not reach back to anal.

Genus LEPTOSCUS Gill, 1859.

*Leptoscopus macropygus* (Richardson). Star-gazer. (Fig. 7).

*Uranoscopus macropygus* Richardson, *Voy. Erebus and Terra*, p. 55, 1846.

*Uranoscopus maculatus* Richardson, in *Dieffenbach's Travels N.Z.*, 2, p. 207.

*Leptoscopus huttonii* Haast, *Trans. N.Z. Inst.*, 5, p. 275, pl. 16.

*Leptoscopus tricolor* Haast, *Trans. N.Z. Inst.*, 5, p. 276.

*Leptoscopus macropygus* Rich.: Hutton, *Trans. N.Z. Inst.*, 6, p. 106, 1874; *ibid.*, Waite, *Rec. Cant. Mus.*, 1, p. 29, 1907; *ibid.*, Philipps, *N.Z. Journ. Sci. and Tech.*, 4, p. 123, 1921; *ibid.*, Thomson, *Hist. Portobello Fish Hatch.*, p. 92, 1921.

D 31-32; C. 14; V. 1 + 5; A. 36-37; P. 1 + 18.

Head (inclusive of lower jaw) 3.75 in total length or less than half height. Head flattened, eyes being on dorsal surface, diameter of eye 2 in pre-oral length. Dorsal originates above middle of pectoral which has 7th ray 1.21 in head. Pectoral well developed and distinctly pointed at 7th ray. Caudal approx. half the head, distinct, and slightly rounded. Anal commences slightly behind and ventral in advance of pectoral origin. Snout to ventral origin is 1.83 in

snout to opercular margin and less than caudal. Anal reaches to precurrent caudal rays.

Tail compressed; depth of caudal peduncle being equal to posterior margin of eye to snout. Pectoral extends to 7th dorsal ray. Lateral line conspicuous arising above operculum, dark olive throughout, scales leaf-shaped with a central ridge.

The star-gazer (*Leptoscopus macropygus*) is one of our common food-fishes. It is most abundant on the large stretch of sandy trawling area off Westport, Hokitika and Greymouth, being commonly seen exposed for sale in the latter town. The species is also not uncommon at Napier; but does not seem to be in demand as a food fish. Large examples may be over 2 feet long; but the average size is not more than half this.

## FAMILY PARAPERCIDAE.

Genus PARAPERCIS Bleeker, 1863.

*Parapercis colias* (Forster). Blue cod. (Fig. 8).

*Gadus colias* Forster in Block and Schn., *Syst. Ichth.*, p. 54, 1801.

*Percis colias* Forster: Richardson, in Dieffenbach, *Travels in N.Z.*, 2, p. 207, 1843; *ibid.*, Hutton, *Fishes of N.Z.*, p. 25, fig. 38, 1872; *Trans. N.Z. Inst.*, 22, p. 279, 1890; *ibid.*, Sandager, *Trans. N.Z. Inst.*, 20, p. 129, 1888.

*Parapercis colias* Forster: Gill, *Mém. Nat. Acad. Sci.*, 6, pp. 99 and 118, 1893; *ibid.*, Hutton, *Index Faunae, N.Z.*, p. 43, 1904; *ibid.*, Waite, *Rec. Cant. Mus.*, 1, p. 29, 1907 and 1, p. 244, 1911; *ibid.*, Phillipps, *N.Z. Journ. Sci. and Tech.*, 1, p. 270, 1918; 4, p. 123, 1921; 5, p. 96, 1922; *ibid.*, G. M. Thomson, *Hist. Portobello Fish Hatch.*, p. 92, 1921.

D. 5 + 21; C. 5 + 14 + 5; A. 1 + 16; V. 1 + 5; P. 1 + 18; B. 6; L. lat. 66.

Head is 3.83 and height of body at dorsal origin 5.05 in total length. Lower jaw is slightly longer and maxilla does not extend to vert. beneath anterior margin of eye. Interorbital space 3.54 and anterior margin of eye to snout 2.47 in head. Eye is oval, its greatest diameter being 2 in inter-orbital space. Body is compressed and head flattened to some degree, the depth at caudal peduncle being 2.5 in depth at dorsal origin or 3.3 in head.

Teeth: In each jaw is a strong outer pointed series. Behind this is a broad band of villiform teeth more or less well developed. This band tapers posteriorly in both jaws and is very broad in front, being much more pronounced in upper jaw than in lower.

Fins: Dorsal commences slightly posterior to opercular edge, the first soft ray being 1.5 in height at origin. Caudal slightly rounded, its length being 1.5 times depth of caudal peduncle. Anal commences slightly in advance of posterior margin of pectoral at a point distinctly nearer snout than tail and 2.11 in total length. Pectoral large

and more or less rounded, the third ray being 1.07 in height at its origin.

Scales denticulate, covering body and part of cheeks and opercles. Lateral line bowed over and behind pectoral, extending along median line to base of caudal. Snout and ventral surface of head naked.

Probably on account of its being one of the most common food fishes, no adequate recent description of the blue cod has appeared. The above description was written from measurements and examination of an example 379 mm. long. Clarke's figure of a Hokitika example published herewith shows a blue cod with a distinctly less deep caudal peduncle.

Large groups of blue cod from 300 to 390 mm. are not uncommon in Wellington markets. Most of these appear to come from the Chatham Islands. Another size group 30 to 60 mm. less is also commonly taken in the vicinity of French Pass.

#### FAMILY OSTRACIIDAE.

*Genus* OSTRACION Linnaeus, 1758.

*Ostracion hexagonus*, n. sp. (Fig. 9).

Head is 3.13 in total length or nearly 4 in length to commencement of caudal. Depth of body at centre of eye 2.5 nearly in total length, or just over three times the longitudinal axis of the orbit. Distance from eye to snout greater than half the length of head and equal longitudinal axis of orbit. Vertical diameter of eye is contained just over 9 times in total length. Dorsal surface flattened in dried specimen, interorbital space being equal to length of head, and at a point twice this length from snout being equal across its plane surface with the vertical distance at the same point between lateral and ventral ridges. The lateral and dorsal ridges on each side are more close together.

Fins: The dorsal is missing. The anal had about 15 rays in the adult though only 7 are present in specimen, the others having been broken off. Caudal 10 rays. Pectoral missing. Dorsal had its origin in the posterior portion of the dorsal surface at a point three-quarters the length of body from snout. The anus is underneath with the anal commencing slightly further back than the dorsal. Pectoral commences under posterior portion of eye.

Teeth: Prominent in the upper and outer row are three teeth on each side. A space is between the anterior pair and reveals another tooth behind. All teeth are of a dark brown colour. Each in front in upper jaw is incisor-shaped, small and closely fitted. In front, in the middle of the mandible, two teeth are prominent. These are at least twice as long as those at the sides in the upper jaw and bite on teeth in front in second upper row. The set nature of the carapace and small mouth prevents further examination without complete destruction of considerable part of head.

**Scales:** There are 10 scales on side behind eye to caudal peduncle, and 9 on longitudinal or lateral ridge. From the centre of a typical scale six raised ridges of carapace radiate outwards with almost mathematical precision bisecting each hexagonal side of the scale. The oblique 4 of these ridges go to form sides of the diamond patterns prominent on the sides, while the two lateral ridges form more or less distinct lines running lengthwise which in six instances are raised out of all proportion to the surrounding parts of carapace and define six longitudinal surfaces. Scales become smaller anteriorly and cease at lips, there being 18 scales surrounding edge of oval through which lips and teeth slightly protrude.

**Discussion:** Jordan and Evermann, *Fishes of Hawaii, Bull. U.S. Fish Comm.*, 23, pt. 1, p. 441, 1903, divide the Family *Ostraciidae* as follows:—

- a. Carapace 4 angled.
  - b. Carapace entirely without spines. *Ostracion*.
  - bb. Carapace with two pre-ocular spines and two terminating ventral keels. *Lactoria*.
- aa. Carapace 6 angled. *Arcana*.

From the above table it would appear that our specimen may belong to the genus *Aracana*; but until a fresh specimen is examined, in my opinion, it would be unwise to refer to it as *Arcana* on this character alone. In *Arcana* there is an opening behind anal fin not evident in our specimen.

During a recent visit to the Bay of Islands District, North Auckland, New Zealand, Mr. L. C. Goffe, Waitangi Falls, kindly presented me with the above described new species of *Ostracion* or trunk-fish. It was picked up on a stretch of sandy beach a little to the north of Pahia, and is in a dried condition. The type in the Dominion Museum is 116 mm. long.

## Additions to the Fish Fauna of New Zealand.

By L. T. GRIFFIN, F.Z.S.

Assistant Curator, Auckland Museum.

[Read before the Auckland Institute, 8th April, 1927; received by Editor,  
5th May, 1927; issued separately,  
10th August, 1927.]

(Plates 9-17.)

THIS paper deals with nine interesting species, most of which constitute new records to our fish fauna.

Possibly the spear-fishes will claim the most attention, owing to the fact that they are responsible for bringing New Zealand into such prominence of late as a "Big Game Fisherman's Paradise."

Prior to the appearance of Jordan and Evermann's recent paper\*, the literature on the subject was scattered, and usually of the most meagre character, either insufficient in detail, or, otherwise so unreliable as to make the task of accurately identifying the various species most difficult.

In order to try and determine exactly what species of spear fishes existed in our waters, I was enabled to visit the Bay of Islands in February, 1927, during the height of the season, when many local and overseas anglers were out after big fish. The weather was unfavourable for a good part of the three weeks spent there, but, despite this, I was able to examine the two species described here and several others. I also viewed the remains of a record Broad-bill, *Xiphias gladius*, captured just prior to my arrival at the Bay, and unfortunately disposed of, except the head and sword. From observations I made, both at the Bay of Islands, and lower on the coast, I am satisfied this species is by no means uncommon in our seas.

Altogether, I examined and made accurate notes of ten spear fishes of two species, besides getting measurements of a few extra spears that had been removed from others caught before my arrival. It is the wish of the writer, that the particulars given in these notes may contribute in some way towards clearing up the existing uncertainty in regard to the species of spear fishes inhabiting New Zealand waters.

I take this opportunity of expressing my gratitude to the many willing helpers at the Zane Grey Sporting Club Camp at the Bay of Islands, and especially to Mr. W. S. Lambe, of Sydney, N.S.W., Mr. J. Holmes, of Russell, and Mr. Fred. K. Burnham and Cox Webb, of California, all of whom did everything possible to assist in my researches.

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\* Jordan & Evermann, Occasional Papers, Cal. Acad. Sci. xii., 1926.

## Family CARCHARHINIDAE.

Genus *GALEOCERDO* Mull & Henle, Arch. Naturg. 3, 1, 1837.  
p. 398 (*arcticus*).

*Galeocerdo arcticus*, tiger-shark ♀. (Fig. 1.) *Squalus arcticus*  
Faber, Naturg. Fish. Iss., 1829, p. 17.

*G. rayneri* Macdon & Barrow. P.Z.S. 1868, p. 368, pl. 32.

*G. arcticus* McCulloch. Check-list, Fish. N.S. Wales, pt. 1, p. 6,  
pl. 1, fig. 2a.

Greatest depth, 4 in total to hypural joint. Upper caudal lobe nearly  $2\frac{3}{4}$  in same, and almost equal to distance from anterior margin of first dorsal to anterior margin of second dorsal. Pectoral equals distance from dorsal notch to tip of lower caudal lobe, and  $5\frac{1}{4}$  in total length to hypural joint.

Body of moderate depth, upper and lower profiles sub-equal. A long low keel on sides originating a little in front of ventral, getting higher posteriorly, its greatest height being about one inch. Anteriorly, it is lost below base of first dorsal. A keel about half an inch high extends along the middle line of back between the two dorsal fins. A crescentic pit at root of upper caudal lobe, with a similar one at base of the lower caudal lobe.

Head short, flattened, giving the snout a shovel-like appearance when viewed from the front. Snout short, rounded. Nostrils a transverse slit, with a conical flap attached to the inner side of anterior margin. Mouth somewhat oblique, large, crescentic. A long labial fold in upper jaw. Teeth in jaws sub-equal, about 22 in each jaw, oblique, deeply notched on outer margin, serrated on both sides of the basal half, the tips smooth, directed outwards. Eye small, round, 3 in snout, placed above centre of mouth. Nictitating membrane wide, the upper half coarsely granular. Spiracle small, vertical, linear, situated about twice the orbital width behind the eye. Gill-slits 5, the 4th and 5th above anterior margin of pectoral. Origin of first dorsal fin a little nearer pectoral than centre of fish. The fin is low, thickened. Second dorsal origin slightly in advance of origin of anal. Pectoral thick, leathery, rounded at extremity. Upper caudal lobe long and rather flexible.

*Colour*: Light slate above, creamy white below, with a pinkish patch on side over the ventral. The stripes on the side were not seen when the fish was first captured, but when dry they were plainly observable; I counted 21 on the body. Anteriorly, the stripes did not reach beyond the upper margin of the gill-slits, getting longer towards the middle of fish, thence, shorter towards the caudal.

Described and figured from a specimen captured on rod and line by Dr. Newland, of Adelaide, while the latter was engaged in big game fishing in New Zealand waters. The weight of this fish was 544 pounds. Its length from tip of snout to the hypural joint 9 feet, greatest depth of body 2 feet.

McCulloch describes it as a common and dangerous species, which attains a length of sixteen feet, and that it is widely distributed throughout temperate and tropical seas, often appearing in harbours

and estuaries on the Australian coast. So far as I am aware, this is the first of its kind to be placed on record in New Zealand, but, from my talks with fishermen, I have every reason to believe it to be fairly plentiful in our waters where it is known as the shovel-nose. On examining the contents of the stomach of this fish, it was found to contain two very large crayfish, *Jasus edwardsii*, one blue penguin, *Eudyptula minor*, and a large coarse-haired dog, the size of a collie.

*Locality:* Cape Brett, Bay of Islands, Auckland Provincial District.

### Family MURAENIDAE.

#### Genus GYMNOTHORAX Bloch.

#### *Gymnothorax meleagris* Shaw. (Fig. 2.)

*Muraena meleagris*, Shaw, *Nat. Misc.* pl. 220; *Gen. Zool.* 4, I, p. 32; Richards. *Voy. Ereb. & Terr. Fish.* p. 93.

*Thyrsoidea meleagris*, Kaup, *Apod.* p. 91 (copied from Richardson).

*Thyrsoidea chlorostigma*, Kaup, *Apod.* p. 89.

*Muraena chlorostigma*, Bleek. *Nat. Tyds. Ned. Ind.* 15 p. 160.

*Gymnothorax chlorostigma*, Bleek. *At 1. Icht. Mur.* p. 97, pl. 34, fig. 2.

Head, 4 in trunk, or  $7\frac{1}{2}$  in total. Height of body  $6\frac{1}{2}$  in trunk, or  $12\frac{1}{2}$  in total. Eye,  $12\frac{1}{2}$  in head, or  $2\frac{1}{2}$  in snout; gill-opening rather more than twice diameter of eye. Anterior nassal tube  $\frac{1}{2}$  diameter of eye. Snout  $4\frac{1}{2}$  in head; mouth 2 in same. Body high, moderately compressed, covered with very thick leathery skin. Occipital region elevated, somewhat gibbous in front. Snout blunt, fleshy on top and sides. Cleft of mouth extends far behind the eye. Anterior nassal tubes short, not reaching tip of snout. A series of 3 widely open pores on mandible, and 5 similar ones on ramus. A single large pore above anterior nassal tubes. Teeth stoutly subulate, in upper jaw biserial, outer row unequal in height, with a wide gap about middle of jaw. A series of 5 small conico-subulate teeth on the vomer of unequal height. Palatine teeth 9, the first shortest, two following, longer, thence a series of 6 minute conical teeth on the middle line, the 4th being widely separated from the last two. Teeth of lower jaw are more uniform than those of upper, somewhat smaller, acute, re-curved, about 20 on each ramus with a series of 6 small conico-subulate ones ranged on each side of middle line in front. All teeth depressable. Posterior nostril above anterior portion of eye small, scarcely distinguishable from the single pore above nassal tube. Branchiostegal sac moderately developed. Origin of dorsal fin a little distance before gill-opening. A thick fold of skin extends from it as far as half the distance from gill-opening to eye; the whole fin is extremely thick and leathery. Anal fin low, much thickened and rounded, almost disappearing as it approaches the vent.

*Colour:* Rich chestnut brown, minutely and uniformly speckled or granulated with cream coloured markings of various shapes.

*Locality:* Described and figured from an adult specimen captured at White Island, in the Bay of Plenty, where several others have been taken in the same locality.

*Measurements:* Total length 1020 mm. long from tip of snout to tip of tail. Snout to vent 525 mm., snout to gill-opening 118 mm., greatest height of body at gill-opening 102 mm.

### Family PEMPHERIDAE.

#### Genus PEMPHERIS Cuvier.

#### *Pempheris adpersus* n. sp. (Fig. 3).

Br. 7; D.vi/X; A.iii/XXXI; V.i/V; P.i/XVII; C.xvi/3x3; L, lat. about 73; L, tr. 10x23; gills 4; gill-rakers long, 28 on lower half of anterior limb. Pseudobranchi present. Depth  $2\frac{1}{2}$ , head rather less than  $3\frac{1}{2}$  in the length to the hypural joint. Eye  $2\frac{1}{4}$  in the head; interorbital width 3 in the eye and rather more than 1 in the snout; depth of caudal peduncle  $\frac{3}{4}$  the width of the eye. Distance between origin of dorsal and end of snout is  $\frac{1}{2}$  that from its origin to end of middle caudal rays.

Body deep, the profile gently arched to the dorsal fin, thence fairly straight to the tail. Lower profile forms an even curve to origin of the anal, thence, somewhat oblique to the caudal. Maxillary rather longer than diameter of the eye, and reaching backward to posterior margin of the pupil, its distal portion covered with ctenoid scales. Interorbital space convex. Preoperculum with a single strong flattened spine at the angle. Operculum with three flat points separated by broad excavations. A narrow strip of cycloid scales extends backward from middle of interorbital as far as the origin of the dorsal fin. The rest of the head, with the exception of the tip of snout, is covered with moderate ctenoid scales. A single row of small villiform teeth in both jaws. In the upper, two or three slightly longer hooked canines are found on its top margin, while the lower jaw has three or four similar ones projecting from the extremity of the ramus. A triangular line of small conical teeth on the vomer; and a band of smaller ones on the palatines. Whole body covered with small ctenoid scales which are smaller on the dorsal surface, and between the interradial membranes of the anal and caudal. Lateral line continuous. It is fairly straight from the caudal to below the fifth dorsal spine where it bends rather steeply downward to the operculum. It continues to the end of the middle caudal rays. Dorsal fin with its origin in the vertical from the lower border of pectoral, high, about  $5\frac{1}{4}$  in the total length to end of middle caudal rays. The pectoral reaches backward as far as the last dorsal ray. Origin of ventrals slightly in advance of upper base of pectoral and reaching backward to the anterior margin of the anus.

*Colour in alcohol:* Uniform silvery purple brown on body, covered with minute brown dots which require a lens to view them properly. A few much larger brown dots are found scattered about on the sides of the fish. The ground-colour is somewhat darker on the nape and posterior border of operculum. Dorsal, anal, and caudal, dark

purple brown tipped with black, and covered with minute dark brown dots. Pectorals white, a dark brown band at base. Ventrals white on margins, the middle membrane being light purple and minutely dotted.

Described and figured from a female specimen which is 129 mm. long from tip of snout to hypural joint. Another, but smaller female was taken at the same time, a comparison discloses very little difference. In the paratype, the eye is a little lower in the head, otherwise they are comparative.

*Affinities:* This species approaches very closely to *Pcmpheris affinis* described by McCulloch in Zool. Res. Endeavour Pt. 1, p. 45, pl. 7, fig. 1. A comparison, however, shows important differences between them, particularly in the nature of the scales, interorbital width, and other points of a more or less distinct character, I therefore feel safe in regarding this as a new species.

*Locality:* Two female specimens taken by hand-line at the Bay of Islands, Auckland Provincial District, March, 1926. Holotype and paratype in the Auckland Museum.

### Family THUNNIDAE.

#### Genus GERMO Jordan.

*Germo germo* (Lacépède); Long-finned albacore. (Fig. 4.).

*Scomber germo* Lacépède, *Hist. Nat. Poiss.*, 1803, China Sea; after Commerson.

*Thynnus pacificus* Cuv et Val, *Hist. Nat. Poiss.*, 8, p. 133, 1831, after Lacépède.

*Germo germo* Fowler, *Pro. Acad. Nat. Sci. Phil.*, 1904 (1905), p. 761.

*Germo alalunga* Stead, *Fish. Aust.* pp. 162-165, 1906 (not Gmelin).

*Germo germo* Stead. *Add. Fish. Fauna. N.S. Wales*, 1, pp. 20-21, 1907.

*Thannus* (*Germo*) *germo* Stead. *Edib. Fish. N.S. Wales*, p. 95, 1908.

*Germo germo* Waite. *Rec. Cant. Mus.*, Vol. 2, No. 1, p. 19.

*Germo germo* Thomson. *N.Z. Journ. Sci. & Tech.*, Vol. 1, 1918, p. 7, fig. 3.

*Germo germo* Phillipps. *N.Z. Journ. Sci. & Tech.*, Vol. 4, No. 3, 1921, p. 118, and Vol. 5, No. 2, p. 93, 1922.

*Germo germo* Jordan and Evermann, *Oceas. Papers. Cal. Acad. Sci.* 12, 1926, p. 16, pl. 3, fig. 1.

D.xiv/I/X—8; A.i/XIII—7; P.XXXV; V.i/V Gills, 4; Gill-rakers 22 on lower half of the anterior limb.

Depth before ventrals 4 in total to end of caudal peduncle or rather less than 2 in pectoral, but, equal to width of caudal lobes. Eye  $5\frac{1}{2}$  in the head, and equal to pre-orbital. Distal end of maxillary about half the width of the orbit. Width of caudal peduncle  $\frac{3}{4}$  that of the orbit. Caudal lobes subequal to depth of body. Body oblong, robust, wholly covered with small scales, the dorsal and ventral profiles subequal. A high keel on the caudal penuncle, with a low denticulated ridge above and below posteriorly. Lateral line commencing at upper posterior margin of operculum has a high curve

below the anterior portion of the first dorsal, thence sloping gradually to end of pectoral, where it becomes almost straight to keel on peduncle. Head with the snout somewhat acute, the lower jaw a little the longest. Maxillary extends backward as far as the anterior border of the orbit. Anterior nostril small, oval, placed five-eighths of an inch in front of the posterior one which is a vertical slit five-eighths of an inch in length placed just before the eye. Teeth in jaws sub-conical in a single series. Minute villiform teeth are also present on the vomer palatines and tongue. First dorsal with its origin in the vertical from the ventral, the first and second spines highest, rather more than two in the eye, and subequal with the anterior spine of the second dorsal. It is separated from the second dorsal by a space equal to the width of the eye. Second dorsal falcate, followed by eight separate finlets. Anal falcate, somewhat smaller than the second dorsal, followed by seven finlets. Pectoral long, of fairly uniform width throughout, reaching backward to the vertical from the third dorsal finlet, and lying in a half sheath when pressed against the side. Ventral short, its origin a little posterior to that of the pectoral.

*Colour*: Top of head and upper part of back deep blue, below, uniform steel blue including cheeks and operculum. Eye steel blue with an outer ring of vandyke brown. Lower jaw yellowish-silver. Dorsal spines white streaked with blackish brown, the membrane mainly transparent, but streaked at margins with thin blackish brown. Second dorsal dull blackish blue, the finlets behind being pale yellow bordered with black. Anal white, the finlets dull white streaked with lemon yellow. Ventral white. Pectoral uniform purple blue.

Described and figured from a specimen caught off Cape Brett by Mr. F. K. Burnham, of California, February, 1927. The total length is 615 mm. from tip to snout to the end of the caudal peduncle. The head is 189 mm. long. Greatest depth 150 mm. Pectoral, 260 mm.

*Locality and distribution*: Cape Brett, Bay of Islands, also recorded from the West Coast Auckland Provincial District. Philipps records it from Napier and Gisborne. According to others it is occasionally met with in Australian waters, while Jordan & Evermann record it from Japan, Hawaii, and off the coast of Southern California.

### Family ISTIOPHORIDAE.

#### Genus MAKAIRA Lacépède.

#### KEY TO THE NEW ZEALAND SPECIES.

Stripes on body broad, indistinct.

Dorsal lobe low, little falcate, Median spines moderate, from bottom of groove  $5\frac{1}{2}$  in highest.

Pectoral markedly falcate.

Bony spinules in skin large, pronounced ..... *mazara*.

Stripes on body narrower, very distinct, almost reaching ventral surface.

Dorsal lobe high, markedly falcate.

Median dorsal spines 4 in the highest.

Bony spinules in skin smaller, not so pronounced ..... *mitsukurii*.

*Makaira mazara* (Jordan and Snyder). Black marlin, ♀. (Fig. 5.).

*Histiophorus gladius* Ramsay (nec Broussonet). *P.L.S. N.S. Wales*, 5, 1881, p. 295, pl. 8.

*Tetrapturus mazara* Jordan and Snyder, *Journ. Coll. Sci. Imp. Univ. Tokyo*, 15, 4, 305, May, 1901, Misaki, Japan.

*Tetrapturus indicus* Stead. *Edible. Fish. N.S. Wales*, p. 100, pl. 67.

*Tetrapturus indicus* McCulloch. *Check List. Fish. N.S. Wales*, pt 3, p. 106, pl. 34.

*Makaira mazara* (Jordan and Snyder) Jordan and Evermann, *Occasional Papers, Cal. Acad. Sci.* 12, 1926, p. 53, pl. 2, fig. 1.

D.ii/XXX—7; A.i/VIII—7; P. 20; V.I; Br. 7; Gills, 4.

Depth behind pectoral rather more than 5 in total from tip of spear to end of middle caudal membrane, or nearly  $3\frac{1}{2}$  in body exclusive of head. Head (tip of spear to posterior margin of operculum) nearly 2 in body. Spear to anterior margin of nostril  $1\frac{1}{2}$  in rest of head and equal to greatest height of body, subequal with pectoral, and about twice the length of dorsal lobe.

Eye including orbital width 6 in head. Maxillary  $\frac{1}{2}$  width of eye. Dorsal lobe 2 in body. Median dorsal spines  $5\frac{1}{4}$  in longest. Upper caudal lobe  $\frac{1}{2}$  longer than lower, or equal to pectoral. Ventral  $\frac{1}{2}$  length of pectoral. Depth of caudal peduncle 2 in dorsal lobe.

Body robust, the profile rising rapidly directly above the eye to dorsal, thence sloping gradually to second dorsal. Ventral surface subequal to the dorsal. Skin inclosing numerous lanceolate bony spinules averaging about 16 mm. long. Bucklers on caudal large, flexible. Head: Lower profile and spear somewhat oblique. Tip of lower jaw with a downward curve. Maxillary extends an orbital width behind the eye. Angle of lower jaw almost reaches posterior margin of preoperculum. Cheeks with bony spinules similar to body, but somewhat smaller. Posterior quarter of preoperculum smooth, but, showing broad striae. Operculum smooth. First dorsal with its origin above middle of operculum. The fin lies in a groove which is deep anteriorly, very shallow towards end of fin. Dorsal lobe sub-falcate, spines following getting progressively shorter. The first spine is short, bound to the second by thick leathery membrane, while the last is very small, hidden by the groove which terminates at this point. Whole of membrane covered with spots ranging from half an inch to three-quarters in diameter, few of which partly cover the spines. The spots are uniformly round, their margins but little diffuse.

Second dorsal separated from first by a space equal to two of the eye. The fin is thickened by tough flexible skin, the last spine produced. First anal in a deep groove similar to dorsal which almost hides the fin when folded backward. Second anal slightly smaller than second dorsal, but, similar to it in every other respect. Its origin is a little behind that of the second dorsal. Pectoral markedly falcate, its outer spine longest and sharp on margin. Its origin is the vertical from the fifth dorsal spine, extending backward to the vertical from the nineteenth and twentieth. Ventrals reduced to a single flattened spine, broad at base, tapering to an extremely fine point. They are covered with small flattened papillae on both surfaces. Their origin is below the middle of pectoral base, reaching backward to the vertical from the fifteenth dorsal spine, fitting very perfectly into a narrow groove on the abdomen. They are seldom

equal in length, one usually being half an inch to an inch longer than the other. Caudal similar in character to pectoral, the upper lobe longest; there is a deep notch at the base.

*Colour*: Dorsal blackish blue, getting thinner towards the middle of the height, where it has a light brassy hue over dull silver. Below this, it is dull bluish silver, ending in a narrow white band along the middle of the ventral surface. About fourteen broad indistinct stripes on body, reaching down to middle of operculum anteriorly, getting gradually shorter as they approach the caudal. A few more short and more indistinct stripes are disposed among the others, irregular in shape, and often difficult to define. Cheeks and operculum bluish-silver maxillary the same. Eye brilliant bluish-silver. Lower jaw dirty silver white. Spear blackish-blue above, ochreous on the under surface. Dorsal fin deep violet at base, the membrane brownish in patches with thin streaks of dull blue towards tips of spines. Dorsal spots very dark purple brown. Thickened membrane of anterior part of dorsal blackish-blue. Second dorsal blackish-blue. Anal similar to low dorsal, but without spots. Second anal light greyish-blue. Pectoral dark blue on outer surface, dull greenish silver on the inside. Ventrals black, the papillae covering them greyish-brown. Caudal similar to outer surface of pectoral.

Described and figured from a female specimen weighing 472 lbs. Total length from tip of spear to end of caudal membrane, 9 feet 6 inches. Spear from anterior margin of nostril,  $23\frac{5}{8}$  inches. Greatest height of body  $23\frac{1}{2}$  inches. Greatest thickness  $11\frac{1}{2}$  inches. Width of caudal lobes,  $37\frac{1}{2}$  inches.

*Identity and variation*: This fish agrees so well with descriptions given by Jordan and Evermann, that I have no doubt about it being the same species. It is subject to some variation similar to other members of the family. It approaches very closely to *M. marlina*, but the very fact that the last named is said to have no stripes on body, or spots on its dorsal fin, excludes it from being this species. According to the descriptions, the variation of the dorsal fin is great, viz: from 40—52. Those I have examined average 32 only.

*Locality and distribution*: From the North Cape to the Bay of Plenty, New Zealand, from January to April. The specimen described here was taken off Cape Brett, Bay of Islands; in February, 1927, a locality where many have been taken by anglers during the last few years. It is also said to be abundant in the open waters about Hawaii, from whence it probably migrates to New Zealand and Australian seas. It has only once been recorded from Japan, the original type, from Misaki.

*Sexual conditions*: The reduced state of the ovaries in the specimen described indicate that it was far removed from the breeding condition.

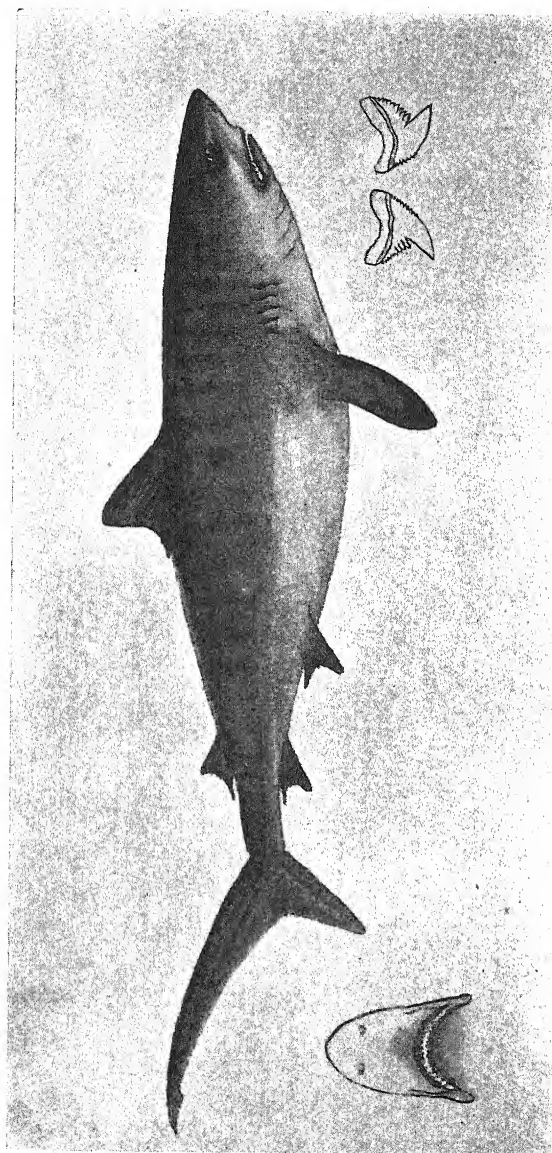
*Makaira mitsukurii* (Jordan and Snyder), Spear-fish. ♂. (Fig. 6.).  
*Tetrapturus mitsukurii* Jordan and Snyder, Journ. 4., Coll. Sci. Imp.  
Univ. Tokyo. 15, pt. 2, 303, pl. 16, fig. 5, 1901, Misaki Sagimi,  
Japan.

- Makaira mitsukurii* (Jordan and Snyder). Jordan and Evermann, Occasional Papers, *Cal. Acad. Sci.* 12, 1926, p. 61, pl. 18.  
*Makaira zelandica*, Jordan and Evermann, Occasional Papers, *Cal. Acad. Sci.* 12, 1926, p. 65, pl. 19, fig. 2.  
*Istiophorus gladius*, Phillipps (nec Broussonet). *Trans. N.Z. Inst.*, Vol. 65, 1926, p. 536, pl. 92.

D.iii/XXXVIII—6; A.i/XII—5; P.XX; Br. 7; Gills. 4.

Depth behind pectoral equal to the dorsal lobe,  $\frac{3}{4}$  length of spear, and about  $5\frac{1}{4}$  in total from tip of spear to end of caudal membrane, or rather less than  $3\frac{1}{4}$  in body exclusive of the head. Head, including spear, rather more than  $1\frac{1}{2}$  in body, and little less than 2 in height. Lower jaw  $\frac{3}{4}$  the height of body. Spear from tip to anterior margin of nostril equal to the pectoral, subequal with the upper caudal lobe, or  $2\frac{1}{2}$  in body from posterior margin of operculum to end of caudal membrane. Pectoral a little shorter than distance from tip of lower jaw to end of operculum. Ventrals  $\frac{3}{4}$  the length of lower caudal lobe, and nearly as long as anterior dorsal. Caudal lobes wide,  $2\frac{3}{4}$  in the total length. Median dorsal spines  $4\frac{1}{4}$  in the longest. Eye, including the orbital width  $5\frac{1}{4}$  in rest of head. Maxillary about  $\frac{1}{2}$  of the eye.

Body robust, highest anteriorly beneath the dorsal lobe, thence sloping gradually to the 30th spine. It then rises somewhat, having the appearance of a small hump upon which is placed the second dorsal fin. Greater part of the ventral surface evenly convex except in the position of the two anal fins where it is oblique. About seventeen very distinct stripes about  $1\frac{1}{2}$  inches wide cover the dorsal surface and sides, most of which almost reach the ventral surface. There are also a few shorter shadow stripes on the dorsal surface only, disposed irregularly between the longer ones. The skin of body is full of small lanceolate overlapping spinules. From the dorsal fin to the spear, the top of the head slopes with a gentle curve. The spear is almost straight, the extreme tip only being slightly upturned. Base of spear before the eye broad, rounded on top, and somewhat flattened below. Tip of lower jaw fits close to the upper when the mouth is closed. Maxillary extends half the width of the orbit behind the eye. Cheeks with small spinules similar to those found on body, but, the broad posterior margin of the preoperculum is mostly smooth, showing marginal striae only. Operculum smooth. First dorsal origin above upper angle of operculum, the anterior portion high, falcate, the three anterior spines bound together by thick membrane. The whole fin is contained in a groove which is of moderate depth anteriorly, about one-eleventh in the height of the body. It gradually decreases in depth towards the posterior portion of the fin. Second dorsal placed on a low hump, behind which, at base of caudal, there is a shallow pit. The first anal is also contained in a groove which hides all but the margin of the first spine when the fin is laid back. Origin of second anal a little behind the origin of second dorsal; it is similar to the latter in every other respect. Pectoral long, moderately straight on its inner margin. Its origin is below the sixth dorsal spine, and it extends backward to the vertical from the twenty-second. The origin of the ventral is below



[L. T. Griffin, del.]

FIG. 1.—*Galeorhynchus arcticus*, Mull & Henle.  
Tiger Shark. ♀ "Greatly Reduced."

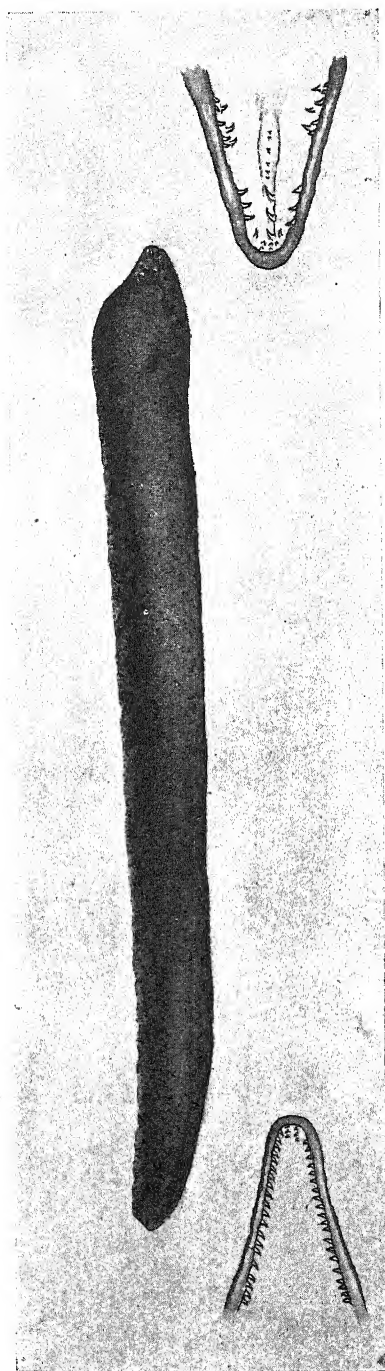
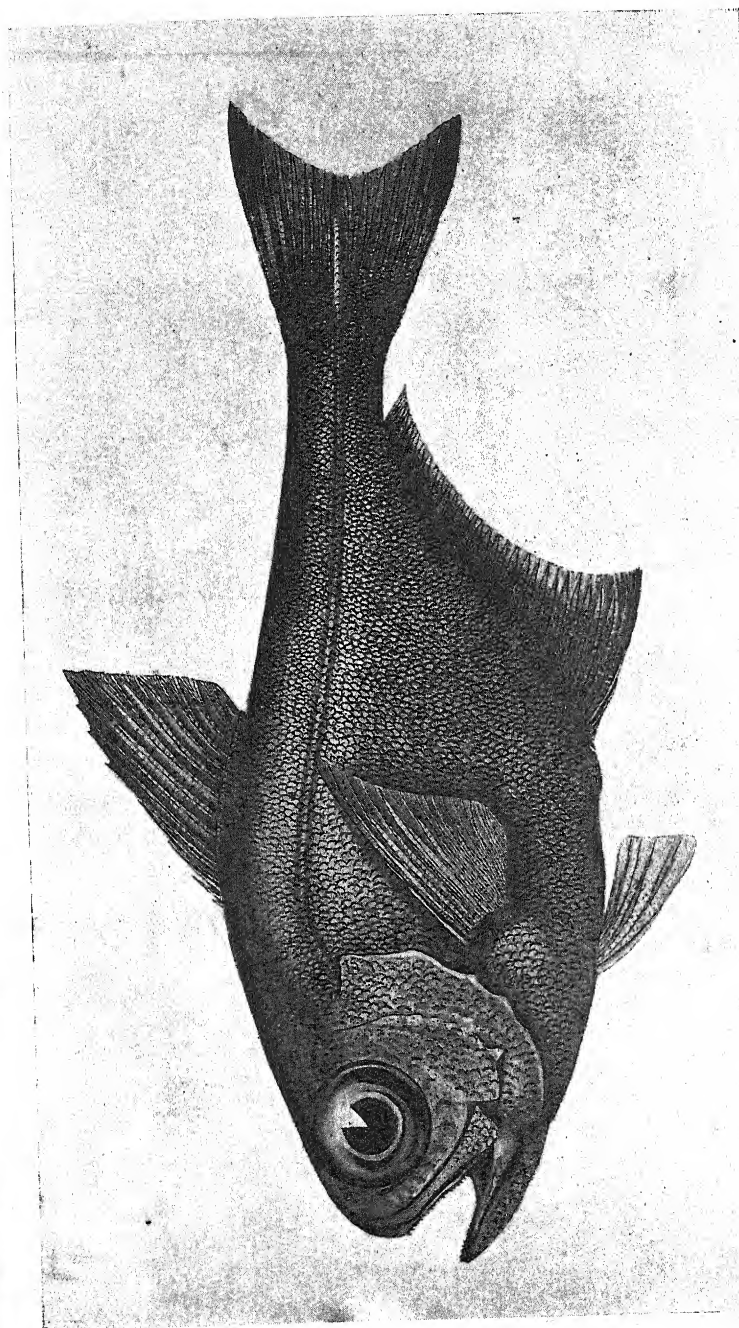


FIG. 2.—*Gymnothorax meleagris*. Shaw. "Reduced."

[L. T. Griffin, del.]



L. T. Griffin, del.

FIG. 3.—*Pempheris aspersus*, n. sp.  
"Slightly Reduced." (Female).

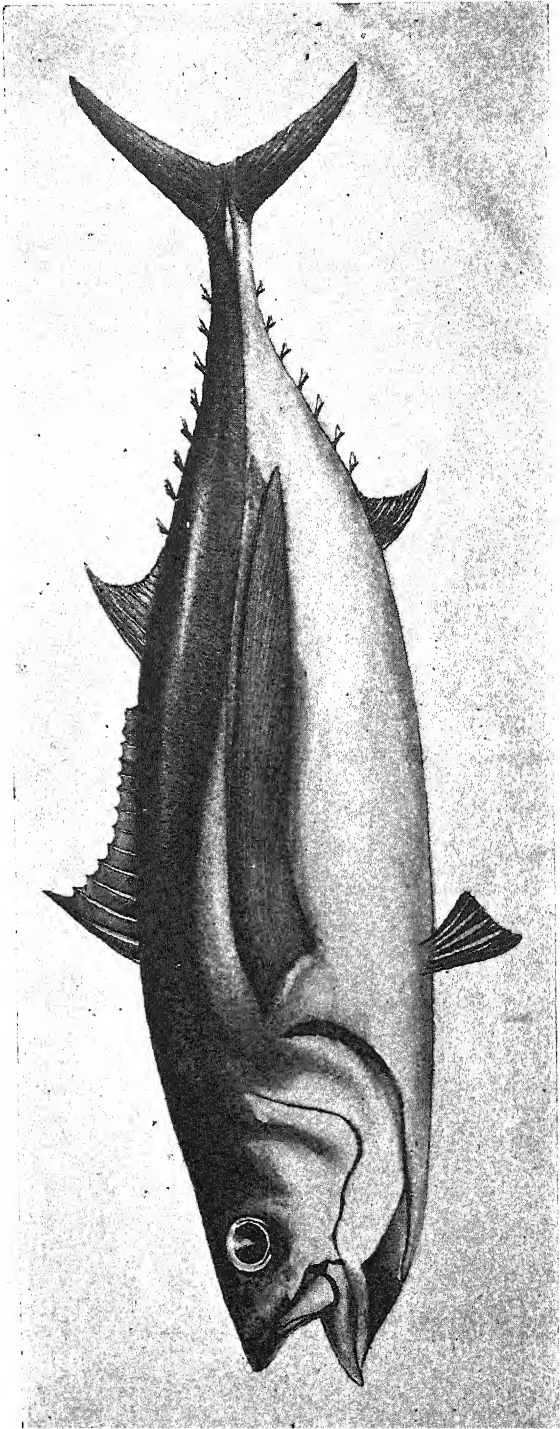
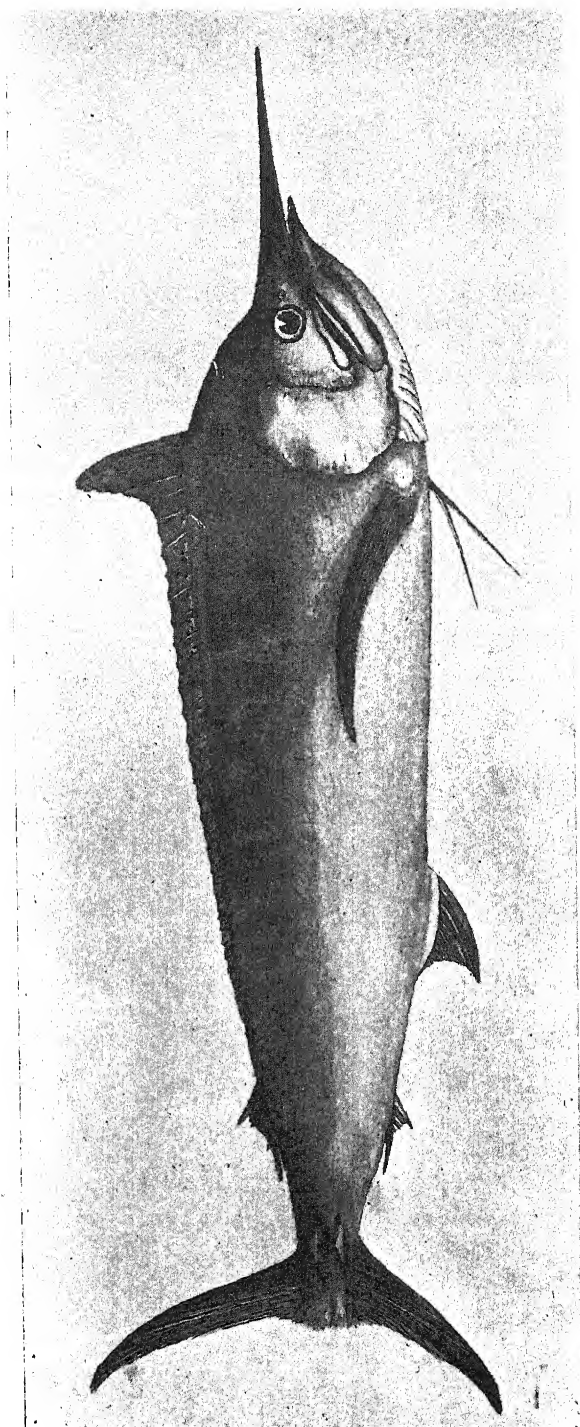


FIG. 4.—*Germo germo* (Lacépède). Long-finned Albacore. "Reduced."

[L. T. Griffin, del.]



Lt. T. Griffin, del.

FIG. 5.—*Makaira mazara* (Jordan & Snyder). Black Marlin ♀.  
"Greatly Reduced."

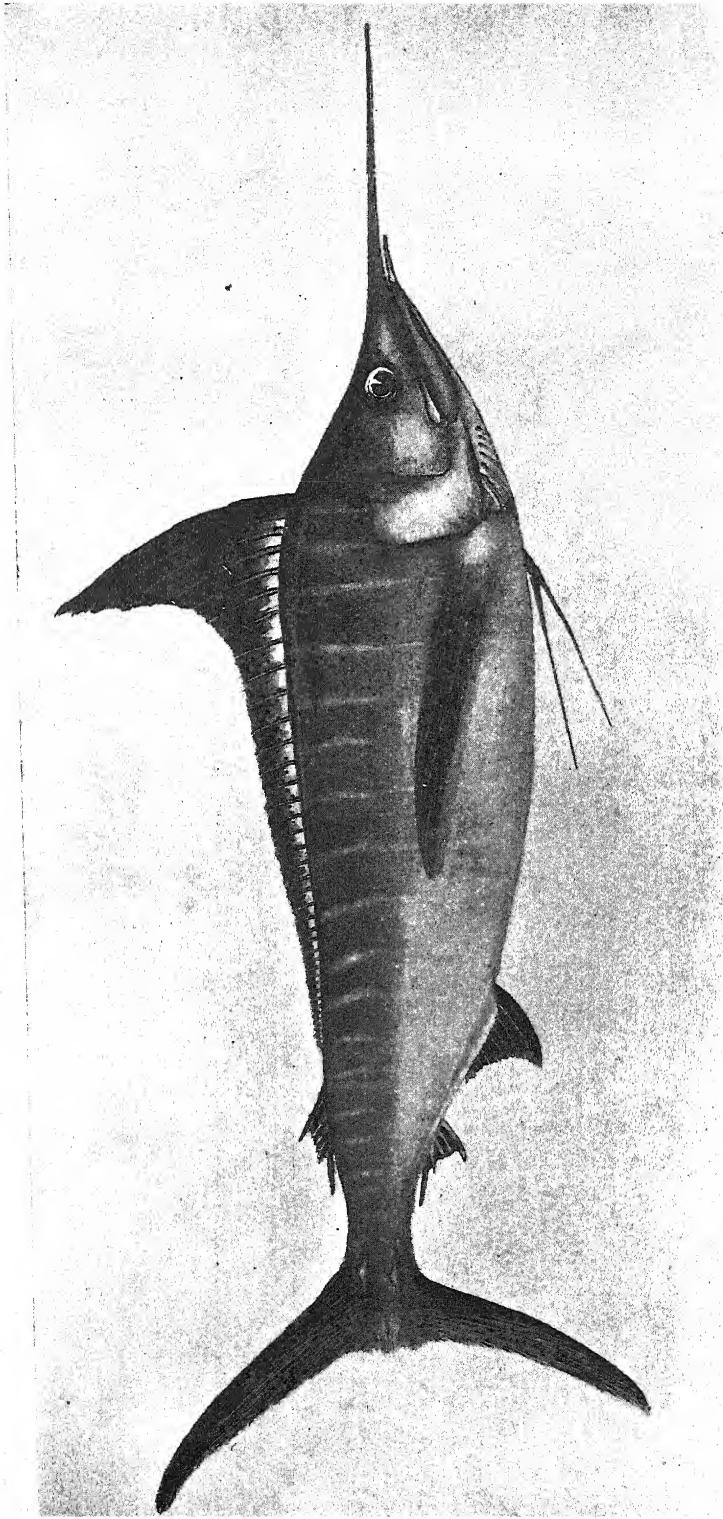
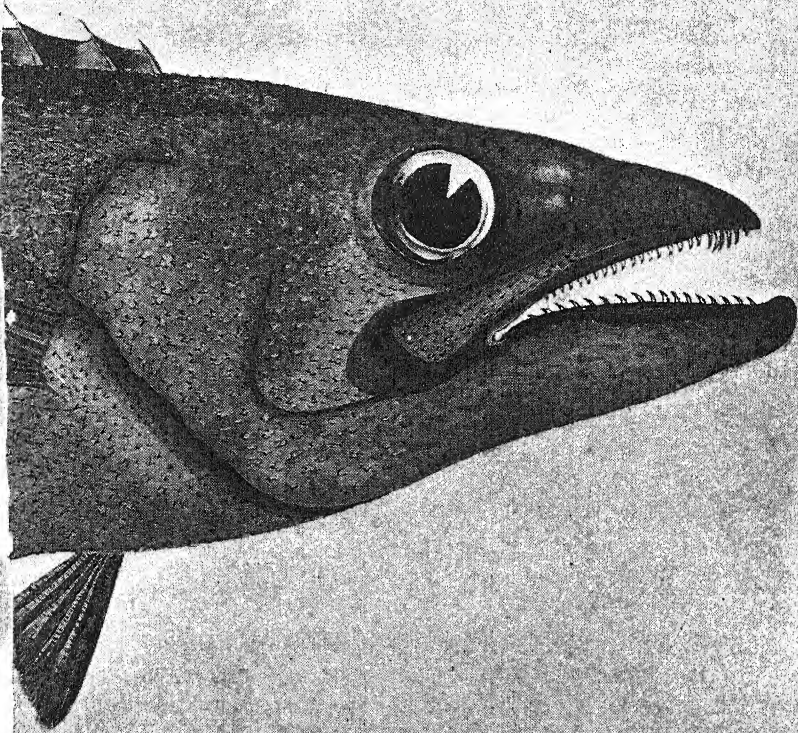


FIG. 6.—*Mahaira mitsukurii* ♂ (Jordan & Snyder).  
“Spear-fish.” Greatly Reduced.

L. T. Griffin, del.



[L. T. Griffin, del.]



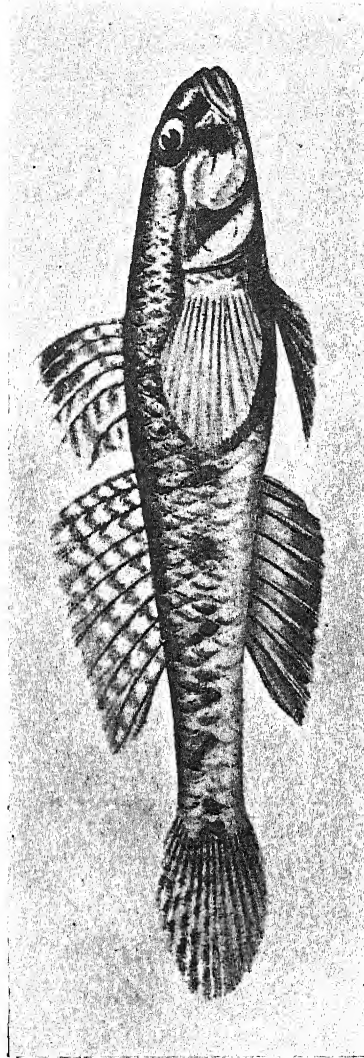


FIG. 8.—*Gobius lateralis* Macleay. (var. *Obliquus*.) *Phyllis Clarke, del.*

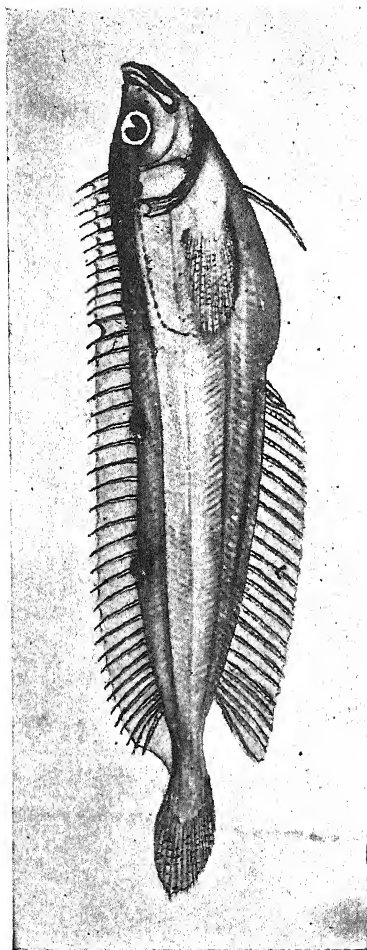


FIG. 9.—*Ophioclinus venusta* ♀ n. sp.

[L. T. Griffin, del.]

the middle of base of pectoral, it extends backward to the vertical from the fifteenth dorsal spine. Caudal with the upper lobe longest. Both lobes are similar in form and structure to the pectorals.

*Colour:* The colour taken from the fish when alive is as follows:—Dorsal above middle of the height to base of dorsal fin, blackish-blue, with a slight bronze outer shade. Near the base of the dorsal fin it is deepest in colour, getting gradually lighter towards the middle of the fish. It then blends into a beautiful pale greenish cerulean-silver which extends as far as base of pectoral, then follows a strip of dull pale bluish-silver as far as the middle line of the abdomen, the latter being pure white. Stripes on sides, pale cerulean-blue of a uniform tint, showing brightly on dark dorsal, but somewhat weaker in tone as they extend towards the ventral surface. The shadow stripes between are of a much lower tone.

Dorsal fin with a broad band of bright violet silver extending the whole length of the base, the membrane and spines above are dark purple blue, streaked in many places with ultramarine. Spots on membrane very dark brown, almost black, they are no larger than a pea, some smaller. The anterior spines of the dorsal are mostly blackish-blue, the membrane between streaked with ultramarine. Second dorsal, uniform dark purple-blue, the produced spine blackish towards the tip. First anal with the largest spine light purple-brown, the spines and membrane behind dark brown with ultramarine blue at the base. Second anal similar to second dorsal, but somewhat lighter in colour. Outer surface of pectoral same as back of fish, the under surface being bright silver blue.

Ventrals blackish-blue. Caudal dark purple-brown with blue streaks between the rays.

Upper surface of spear blackish-blue, the tip light brown. Under parts, and inside mouth, yellowish-pink, almost ochreous. A triangular patch on base of spear before the eye, brilliant silver shot with pale green and cerulean blue. Cheeks and opercles the same colour. Maxillary somewhat deeper. Eye burnished silver streaked with cobalt. Lower jaw dull silver-white, branchiostegal membrane the same, but the rays are frosted with dull silver.

Described and figured from a fine male specimen weighing 381 pounds. Total length from tip to spear to end of caudal membrane is 9 feet 6 inches. Tip of spear to anterior margin of nostril 25½. Greatest depth 18½.

*Stomach contents:* When examined, these fish were found to have been feeding on *Caranx georgianus*, and *Mustelus antarcticus*.

*Identity and variation:* Having recently examined several of these fine fish, and after making full allowance for variation which I found considerable in the various descriptions as well as in the specimens themselves, I have come to the conclusion that this fish compares more exactly with the descriptions of *M. mitsukurii* than any other members of the family. The variation between the male and female in size and form is not great, the females being not quite so deep in the body or as thick through as the males. Females of from eight to nine feet in length averaged about 8½ inches in thickness, while males of the same length went from 9 to 10¾ inches. Males are also deeper

in the body below the dorsal lobe. The spear shows a considerable variation. In seven specimens, six of which were females, I found the following differences in the length of the spear. Measurements taken from tip of spear to anterior margin of nostril:—

No. 1 .....	Weight	325 lbs.	.....	Spear	25 Inches.
No. 2 .....	"	318	" .....	"	22 "
No. 3 .....	"	328	" .....	"	23 $\frac{7}{8}$ "
No. 4 .....	"	348	" .....	"	25 $\frac{3}{4}$ "
No. 5 .....	"	316	" .....	"	25 "
No. 6 .....	"	345	" .....	"	22 $\frac{3}{4}$ "
Male. No. 7 .....	"	381	" .....	"	25 $\frac{5}{8}$ "

The eye also varied in relation to the number of times it would measure in the head. Including the orbital width, it varied from  $4\frac{3}{4}$  to  $5\frac{1}{4}$  times to posterior margin of the operculum. The dorsal fin counts in all the above mentioned fish varied from 3/37 to 3/39. In one of these specimens the pectoral of one side was three inches shorter than its fellow on the other side. The fin was perfectly formed and undamaged. In the Auckland Museum there is a mounted specimen described by Dr. Starr Jordan from a photograph as *M. zelandica* n. sp. I have made a careful examination of this fish, and find it agrees in all essential details with *M. mitsukurii*. The photograph was misleading, as the fins are shrunk and out of position, while the colour is entirely wrong.

*Sexual condition:* The ovaries of females of this species were all found to be in exactly the same undeveloped state as in the previous species described, showing that these fish were far removed from the breeding condition.

*Locality and distribution:* This species is considered the most common and widely distributed of the group. It is common in Japanese waters, Hawaii, and the Santa Barbara Islands. It is said to be found in New Zealand waters during the winter months, but this statement requires verifying. As the records show, it is here from December to April, the greater number being captured during the month of February. It may be taken from the North Cape to the Bay of Plenty on the East Coast of the North Island.

The specimen described and figured was caught in February, 1927, off Cape Brett, Bay of Islands, where a large number were captured during the same month in 1926.

### Family GEMPYLLIDAE.

#### Genus RUVETTUS.

#### *Ruvettus whakari*, n. sp. (Fig. 7.)

D.xiv/XVIII/1/2; A.xvii/1/2; P.XIII; V.i/V; C.XIX. Br. VII.

Above lateral line, about 83 bony scutes between posterior margin of operculum and hypural joint; transverse series of same, about 14 above, and 30 below lateral line taken behind pectoral. Depth before ventrals,  $5\frac{1}{2}$  in total including head; head rather less than  $3\frac{1}{2}$  in same. Eye rather more than 5 in head, and not quite 2 in snout.

Maxillary slightly more than half diameter of eye. Interorbital space  $4\frac{1}{2}$  in head. Caudal peduncle as wide as eye and  $21\frac{1}{2}$  in total.

Body moderately compressed, elongate, fusiform, covered with numerous bony dermal productions which are more crowded below lateral line than above it, each terminating in two or more fine spines. They are small along base of dorsal, top of head, operculum and cheeks, but get gradually larger towards middle of fish, those below lateral line being largest. Scales on anterior portion of cheeks, maxillary, and lower jaw, are more embedded than any of the others. No scales are found on anterior part of head before the eyes, and there is no denticulated keel on the abdomen. Lateral line distinct. Commencing at upper margin of operculum, it bends somewhat steeply downward behind pectoral, then passes fairly straight to caudal peduncle. Maxillary a little short from the verticle of posterior margin of eye. Premaxillary naked on anterior border, but small scales are found on its inner margin. Anterior nostril almost round, situated nearer eye than tip of snout. Posterior nostril an oblong slit, placed a short distance before the eye, its length being  $\frac{1}{4}$  that of the orbit. Teeth re-curved, subulate, the upper jaw with an outer series of 24, the largest of which is only half the length of those in the lower jaw. A group of 5 strong curved teeth on vomer; a row of 14 short curved teeth on outer margin of palatine bones; a single short tooth in centre of anterior margin of palate. Lower jaw projects considerably beyond the upper, furnished with 19 teeth in a single series. All teeth are depressable. Tongue smooth. Posterior angle of preoperculum minutely serrated. Gills 4; gill-rakers very unequal, 13 on lower half of anterior limb, the last of which is elongate, its point furnished with a cluster of minute spines. Origin of dorsal fin in line with upper margin of operculum. The fin is placed in a low groove, and composed entirely of flexible spines, the first, short, less than  $\frac{1}{2}$  the width of the eye. They get gradually longer backward, the 6th being longest, equal to the width of the eye. The 5th and 7th are equal, they then decrease gradually backward, the 14th being about  $\frac{1}{4}$  the width of the eye. First three rays of second dorsal are simple, flexible, the remainder branched, the last separated by a wide notch and united by membrane. Separated from the second dorsal by a space  $\frac{1}{2}$  the width of the eye is a single finlet, this is followed by two others, separated by a similar space, and united by membrane for about  $\frac{1}{2}$  their length. Anal fins similar to second dorsal, but somewhat smaller. Pectoral pointed, reaching backward to the verticle from the 7th dorsal spine. Caudal forked, the upper lobe very little longer than the lower.

*Colour:* Dark purple-grey on dorsal, getting a little lighter towards the middle of the height, thence gradually lighter to abdomen which is a dirty white stippled with light purple. Bony scutes uniform dull cream-colour.

Described and figured from a specimen which is 1,120 mm. long from tip of snout to hypural joint. Greatest height behind pectoral 226 mm.; diameter of eye, 56 mm.; width of caudal peduncle, 50 mm.

*Locality:* White Island, Bay of Plenty. Captured by hook and line by the employees of the sulphur-works at that place. From

reports I have received, five others have been taken on the same ground, it therefore appears to be not uncommon with us although never previously recognised.

The skeletal structure of this fish shows that it is a species inhabiting great depths. All the bony parts are extremely flexible and sponge-like, and may be bent at any angle without breaking. Poey tells us it can be caught only at a depth of 300 fathoms, while Lowe states it is found at depths varying from 300 to 400 fathoms at Madiera. Poey further states that when one of these fishes is brought to the surface it appears to be surrounded by a globe of phosphorescent light. The specimen here described was said to emit a bright phosphorescent light from its large eyes only.

I have specifically named this fish after the place of its capture "Whakari," commonly known as White Island, an active volcano in the Bay of Plenty. Holotype in the Auckland Museum.

### Family GOBIIDAE.

#### Genus GOBIUS Linn.

*Gobius lateralis* Macleay var *obliquus*. (Fig. 8.) *Pro. Linn. Soc. N.S. Wales*, 5, 1881, p. 602.

*Rhinogobius lateralis* McCulloch and Waite, *Rec. S. Aust. Mus.*, 1, 1, 1918, p. 48 pl. 2, fig. 3.

*Gobius lateralis* var *obliquus* McCulloch & Ogilby, *Rec. Aust. Mus.* 12, 1919, p. 249, pl. 34, fig. 4.

D.vi/I/IX; A.  $\frac{I}{IX}$ ; V.v; P.xv; C.xii, 4/4; L. lat. 30; Gills, 4;  
Gill-rakers, 7 on lower half of anterior limb; Br. 4.

Depth of body behind pectoral nearly 7 in total to the hypural joint; head 5 in same. Eye 5 in the head, and subequal with the snout. Body somewhat compressed, covered with rather large ctenoid scales. Shoulder-girdle smooth. A single row of scales at the base of pectoral. Dorsal and ventral profiles subequal. Head rather flat, a little broader than deep, naked on top, cheeks and operculum also naked. Eyes rather large, almost meeting on top, the interorbital space being less than a quarter the width of the eye. Villiform teeth in both jaws, the upper, with an outer series of longer hooked teeth followed by two rows of much smaller ones behind. Teeth in lower jaw similar to those of the upper, but more minute behind the outer series, with one or two slightly longer ones scattered about. Anterior spines of the first dorsal equal to the anterior rays of the second, the spines and rays following in both fins getting but slightly shorter backward. The second dorsal is separated from the first by an interspace equal to half the width of the eye. Anal origin is the vertical from the first ray of the second dorsal. It is similar to the latter in form, but smaller. The inner rays of the ventral reach the vent. Pectoral large, rounded, reaching backward to the vertical from the interspace between the two dorsal fins. Caudal similar to the pectoral.

*Colour*: Reddish-yellow, minutely dotted with dark brown on the head, and with dark brown mottling below and before the eye, and behind the preoperculum. A series of dark brown lateral markings on sides of body, commencing behind the pectorals and ending on the caudal peduncle, these are either vertical or oblique, that on the peduncle being nearly triangular. Dorsal, caudal and ventrals barred with dark brown. Anal uniform light brown.

Described from a specimen 41 mm. long from tip of snout to the hypural joint.

*Affinities*: This fish closely resembles *G. lateralis* Macleay, but by careful comparison with its var *obliquus*, McCulloch and Ogilby, I am of opinion it agrees with the latter description best, and especially so in regard to the colour and form of the lateral markings on the body.

The fine plate accompanying this description is by Miss Phyllis Clarke. It is so correct according to my specimen, that I have taken the liberty of reproducing it.

*Locality and distribution*: St. Hellier's Bay, Auckland. Five specimens obtained in February, 1927, by Mr. Lansley Pycroft. Also from New South Wales and Lord Howe Island.

### Family BLENNIIDAE.

#### Genus OPHIOCLINUS Castlenau.

#### *Ophioclinus venusta* n. sp. ♀. (Fig. 9.)

D.xii/XXVII/I; A.ii/XXIII; C.xv, 4/4; P.XIII; V. 2; Br. 5;  
Gills. 4; Gill-rakers 8, on lower half of the anterior limb.

Head  $5\frac{1}{2}$  in the total to the hypural joint, eye  $3\frac{1}{2}$  in the head or 1 in snout. Greatest height of body 5 in the total to the hypural joint. Interorbital space subequal with the eye. Ventral equal to 2 of the eye. Body elongate, compressed, taeniiform, with a series of four longitudinal ridges, between which the muscular structure is well marked by many short oblique lines. Scales minute, scarcely apparent, deeply imbedded. Lateral line very short. Commencing at upper angle of operculum, and curving backward to the posterior margin of pectoral where it ends abruptly. Head naked, gill-membrane united, free from isthmus. Eye lateral, large, placed high up near profile. Interorbital space convex. Anterior nostril minute, placed on margin of the preorbital. Posterior nostril also minute, situated just before the eye. No tentacles are found on either nostril. Maxilla very small, reaching backward to the anterior border of the orbit. In the upper jaw, there is a broad fraenum with a cluster of very short pointed teeth in front in about three series. These are followed by fifteen small curved teeth on each side of the jaw. A patch of minute teeth are found on the vomer, none on the palatines. In the lower jaw, there are fourteen small obtuse teeth on each ramus, with a small patch inside anteriorly. Origin of dorsal fin anterior to the middle of the operculum. It is composed wholly of spines, the membrane of the first six being lower than that following behind.

There is a distinct notch between the twelfth and thirteenth spines, otherwise the fin is continuous. Behind the last spine there is a single ray connecting the fin to the caudal. The anal has its origin in the vertical from the sixteenth dorsal spine. It is formed wholly of soft rays, and is not joined to the caudal. Pectoral short about three-quarters the length of the head, the middle rays longest. Caudal pointed, and similar in form to the pectoral.

*Colour:* When seen in the water, this little fish appears to be of a transparent golden colour, very difficult to detect among the surroundings in a rock-pool. At the base of the dorsal fin there are four dark brown patches, each with a small white spot behind. Head, same as body. Fins transparent golden-yellow. A small spot behind the pectoral.

*Variation:* I have two specimens only of this little fish, and by comparing the holotype with the paratype, I find no variation except in colour. The latter, a male, is of a uniform pale golden tint, without spots at base of dorsal, but there is a small brown streak on one side only at the margin of the pectoral.

Described and figured from a specimen which is 36 mm. long. from tip of snout to the hypural joint. Depth of body  $8\frac{1}{4}$  mm.; eye  $2\frac{1}{4}$  mm.

*Locality:* Found in rock-pools at the Bay of Islands, February, 1927. Holotype and paratype in the Auckland Museum.

The genus *Ophioclinus* was defined by Castlenau in 1873, with *O. antarcticus* as the type of the genus<sup>1</sup>. Two others appear to be known, *O. gracilis*, and *O. gabrieli*<sup>2</sup>. This is the first time the genus has been recognised in New Zealand, and I do not think this species is at all common here. With two days work spent among the rock-pools at the Bay of Islands, I secured only two specimens.

<sup>1</sup> *O. antarcticus* Castlenau. Pro. Zool. Soc. Vict. ii., 1873, p. 69.

<sup>2</sup> *O. gracilis* and *O. gabrieli* Waite. Rec. Aust. Mus. vi., 3, 1906, p. 207, and 208.

## On a Moa Skeleton from Amodeo Bay and Some Moa Bones from Karamu.

By GILBERT ARCHEY, Curator, Auckland Museum.

[Read before the Auckland Institute, May 25th, 1926; received by Editor, 31st December, 1926; issued separately, 13th August, 1927.]

(Plates 18, 19.)

A. IN April of this year Mr. S. C. L. McCall presented to the Auckland Museum a moa skeleton which had been found by his son on the sandhills at Amodeo Bay, Coromandel. The bones represented are the skull, right and left femora, tibio-tarsi and tarso-metatarsi, phalanges, abraded vertebrae (26) and ribs, and fragments of pelvis and sternum.

The similar condition of all of the bones, their agreement in size and their occurrence together, without association with any other moa bones, are sufficient grounds for concluding that they are the bones of an individual bird.

This skeleton is identified as *Cela geranoides* (Lydekker),\* (not of Owen, *Trans. Zool. Soc.* 3, p. 346, 1848), and as the nomenclature of this species is very involved and a new name has to be given in lieu of Owen's original name, it seems desirable to state the successive uses of the names involved in order to establish the validity of the name as used here.

1. The name *geranoides* was first used (as *Palapteryx geranoides*) by Owen (*Trans. Zool. Soc.* 3, p. 346, 1848), who merely gave the number of bones he had before him, the only comment being a footnote "An unpublished species defined from certain leg-bones sent home by the Rev. Mr. Cotton since the communication of my former Memoir, Part II." This does not constitute a valid description, and the name is therefore a *nomen nudum*, consequently *geranoides* cannot be used again in the genus *Palapteryx*, or of the genus of which *Palapteryx* is a synonym. Furthermore Lydekker states (*Cat. Foss. Birds*, p. 288) "These bones were however never described or figured and cannot now be identified."

2. Later in the same paper (*Trans. Zool. Soc.* 3, p. 361, pl. 54) Owen applied the name *Palapteryx geranoides* to a calvarium, pre-maxilla, part of maxilla, and mandibles, which he regarded as a complete skull. A description and figure were given. But the use of the name here cannot stand, firstly because the original application of the name was invalid, and secondly because we cannot know whether the skull is of the same species as the previously named (but undescribed) leg bones.

The name *geranoides* cannot therefore be used for this skull, and some name other than *geranoides* should be applied to it to avoid

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\* (A (?) *geranoides* n. sp. Lydekker, *Cat. Foss. Birds*, p. 288, 1891).

confusion with Lydekker's valid use of the name to be referred to below. I therefore propose the name *Dinornis expunctus*, realising that the future discovery of a similar skull associated with other bones of an individual skeleton may reveal its identity with an already described species.

The synonymy for this proposed name will therefore be:—

*Dinornis expunctus* nom. nov.

*Palapteryx geranoides* Owen. *Trans. Zool. Soc.* 3, p. 361, pl. 54, 1848 (not necessarily of Owen *Trans. Zool. Soc.* 3, p. 346, 1848).

3. The third application of the name was by Owen, as *Dinornis geranoides*, for a metatarsus from Te Rangatapu mentioned by him in *Trans. Zool. Soc.* 5, p. 402, and figured on plate 67, figs. 5 and 6. If this metatarsus is conspecific with skull 2 it would bear the name *D. expunctus*; it is, however, probably *Pachyornis pygmaeus*.

4. Lydekker (1891, *Cat. Foss. Birds*, p. 288), stated that, as the leg-bones originally mentioned by Owen could not now be identified the skull (2) should be regarded as the type [i.e. of *Anomalopteryx geranoides* (Owen)]; but the reasons against this course have been given above. With regard to the other bones he wrote: "The tarso-metatarsus subsequently figured by Owen [i.e., 3 above] as *Dinornis geranoides* may belong to the same form as the skull; but, if not, the undermentioned specimens of the tibio-tarsus may be taken as the actual types of *A (?) geranoides*, which will then rank as a new species." Five bones bearing British Museum numbers are then detailed on p. 289, and their average dimensions given on p. 288. This then is a valid description of *A (?) geranoides* Lydekker, and the specific name can stand as long as the tibiae on which it was founded remain outside the genus *Palapteryx* or of the genus *Dinornis* of which *Palapteryx* is a synonym.

Returning to the Amodeo Bay skeleton I find that the tibiae agree with those of *A (?) geranoides* Lydekker and examination of the associated bones indicates:—

- (a) That the skull 2 above is not of the same species or genus as Lydekker's *A (?) geranoides* and that the latter should be referred to the genus *Cela*; and
- (b) That the metatarsus 3 above is not of this species either. It is probably of *Pachyornis pygmaeus* (Hutton).

4. The tibio-tarsus of this skeleton has the following dimensions:—

Length	.....	.....	355 mm.
Proximal width	.....	.....	110 "
Distal width	.....	.....	?55 " (abraded)
Middle width	.....	.....	29 "
Girth at middle	.....	.....	84 "

The length of this bone is somewhat greater than the average (342 mm.) given by Lydekker, but it is too large for *Anomalornis didiformis* and too small for *Megalapteryx huttonii* (*A. didina*). It also has the inwardly curved distal end characteristic of *C. geranoides* (Lyd.), but is somewhat more slender. This inward curving of the

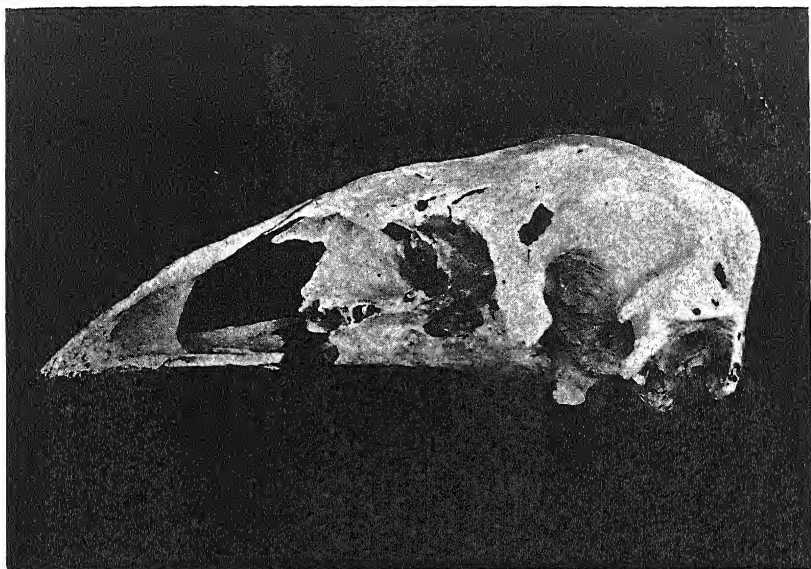


FIG. 1. Skull of *Ceta geranoides* (Lyd.): Side view.

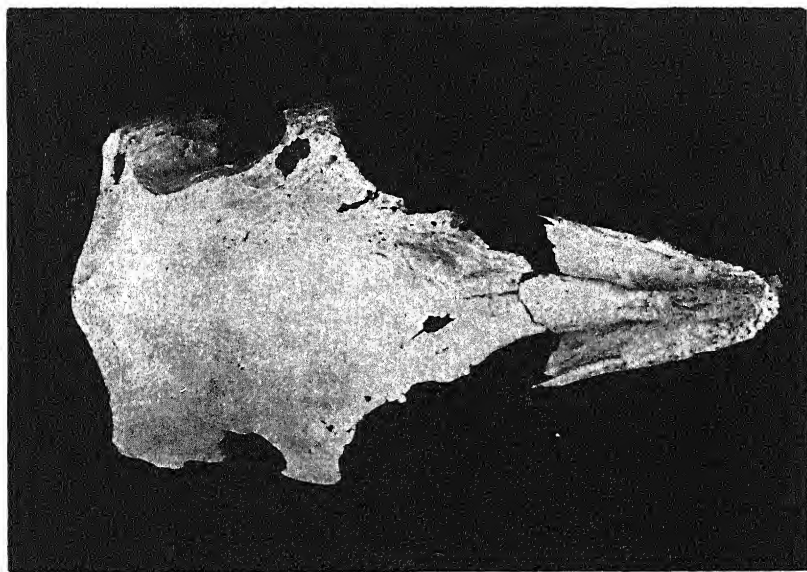


FIG. 2. Skull of *Ceta geranoides* (Lyd.), from above.

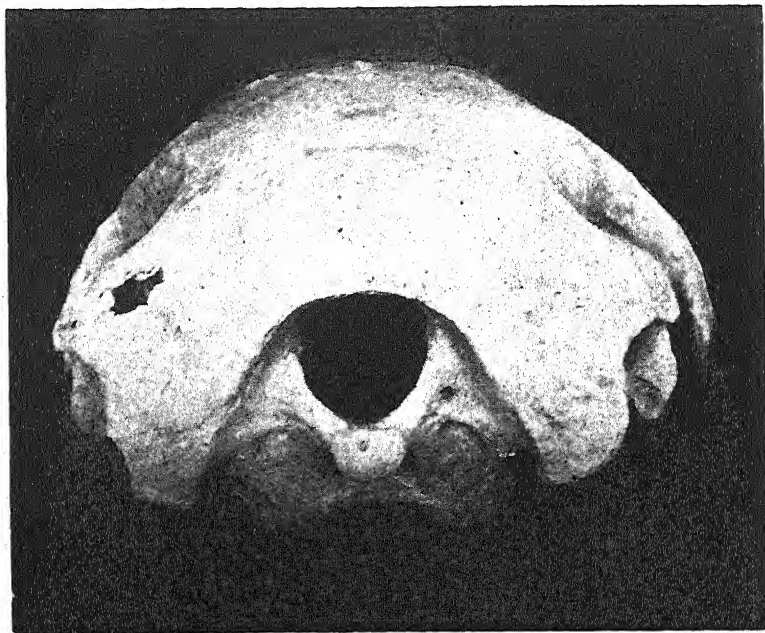


FIG. 3. Skull of *Ceta geranoides* (Lyd.): Posterior view.

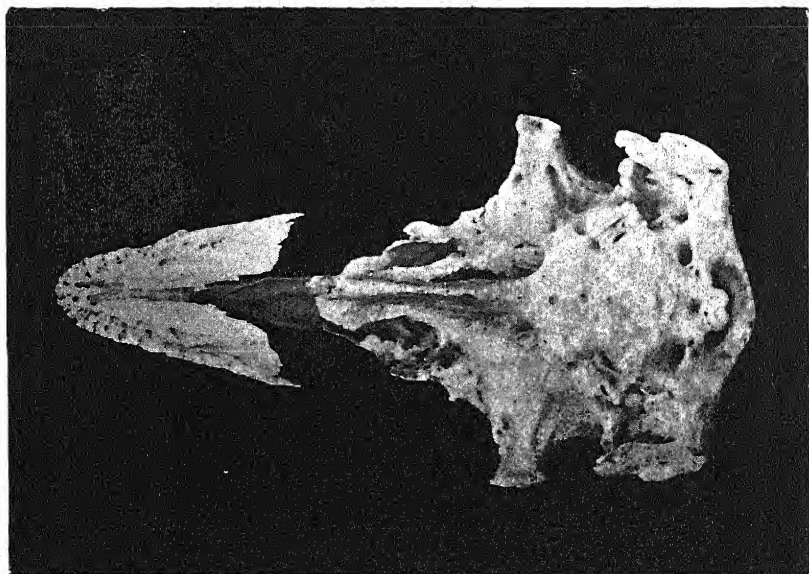


FIG. 4. Skull of *Ceta geranoides* (Lyd.): Ventral view.

distal end is also to be seen though to a lesser degree in the tibiae of *Cela curta*.

The dimensions of the other bones of the leg are:—

	<i>Femur.</i>	<i>Metatarsus.</i>
Length .....	195 mm.	156 .
Proximal width .....	— "	60
Distal width .....	80 "	72
Middle width .....	30 "	31
Girth at middle .....	108 "	81

We see, therefore, that the femur and metatarsus are short in proportion to the tibia, relatively and actually shorter than in *A. didiformis*; i.e., while the tibiae stand between *A. didiformis* and *Megalapteryx huttoni*, the metatarsi stand between *A. didiformis* and *A. parvus*. They are, however, relatively stouter than in these two species and their extremities are more expanded. In these respects they also agree with *C. geranoides* (Lyd.) though the metatarsus is somewhat more slender.

They are much more slender than *Pachyornis pygmaeus* Hutton, which Hutton once united with *C. geranoides*, even taking into consideration the slenderer North Island forms of this species. The result, therefore, of my examination of the leg-bones is to identify them as a slender form of *C. geranoides* (Lydekker). The persistence of the grooves between the units of the metatarsi indicates that this is a not quite mature individual.

*Skull*: The parts of the skull present are the calvarium, premaxillae, mandibles and portions of maxillae.

*Dimensions of the Skull.*

	<i>Measurement.</i>	<i>Percentage of basis cranii.</i>
Total length of skull .....	116 mm.	386
Length of basis cranii .....	30 "	100
Length of roof of cranium .....	68 "	226
Width of cranium at par-occipital processes .....	49 "	163
Width at squamosal prominences .....	59 "	196
Width at temporal fossae .....	43 "	143
Width at post-orbital processes .....	64 "	213
Distance between temporal ridges .....	32 "	106
Height of cranium .....	39 "	130
Width of tympanic cavity .....	18 "	60
Width of temporal fossa .....	25 "	83
Greatest length of premaxilla .....	55 "	183
Length of body of premaxilla .....	25 "	83
Length of mandibular ramus .....	109 "	363
Length of mandibular symphysis .....	16 "	53
Width of mandibular symphysis .....	15 "	50

The profile of the skull (fig. 1) is well arched above the post-orbital and slightly elevated above the prefrontal process; the

temporal fossae extend moderately towards the dorsal profile, but not so far as in *Anomalornis* or *Pachyornis*; the occipital plane is slightly inclined backwards and the occipital crest is prominent.

Seen from above (fig. 2) the occipital condyle is hidden by the supra-occipital; and the temporal fossae extend posteriorly to join the lambdoidal ridge; the distinction between the anterior and posterior lambdoidal ridges is obscure. The space between the temporal fossae is considerably more than half the width at the par-occipital processes. The posterior view (fig. 3) shows the mamillar tuberosities to be considerably prominent, more so than in *Anomalornis*, and the upper margin of the tympanic cavity to be lower than the upper margin of the foramen magnum, whereas they are almost in line in *Anomalornis*. No venous pits (Parker, *Trans. Zool.* 12, p. 384) occur in the precondylar fossa; the par-occipital notch may, or may not, have had a slender bar converting it into a foramen, but as the carotid foramina are still in the condition of being open grooves, indicating a young individual, it is possible that the bridge over the par-occipital notch was not developed; the carotid foramen appears as a deep canal in the floor of the Eustachian groove.

The premaxilla is relatively slender and gently curved in profile, the apex bluntly pointed; it is longer and more pointed than in the type of *C. oweni*. The V-shaped mandible is correspondingly slender and curved in profile, interior and posterior angular processes well-developed.

Except for length and sharpness of the beak in which it resembles *Pachyornis*, this skull agrees with the type of *Cela oweni* Haast, and with a skull identified as *Cela curta* by Captain Hutton, and agrees generally with other skulls referred to *Cela* in profile, extent of the temporal fossae, the prominence of the mamillar tuberosities and the alignment of the upper edge of the tympanic cavity relative to the upper margin of the foramen magnum, in which latter respect however it again resembles *Pachyornis*.

It differs from the skull originally described as *Palapteryx geranoides* by Owen (= *Dinornis expunctus* nom. nov.) in the greater descent of the mamillar tuberosities, the reniform occipital condyle notched above, the foramen magnum being widest vertically, not transversely, and the occipital and temporal fossae not being separated by a smooth area, but with their edges confluent.

In a few skull-characters and in the form of the tibia this skeleton shows an approach to *Pachyornis*, but it is much more slender than species of that genus, while the inward curving of the distal end of the tibia is also exhibited, as above mentioned, by *Cela curta* and *Cela oweni*, and is possibly a characteristic of the genus *Cela*.

Rothschild (*Extinct Birds* p. 189) substitutes *Cela* of Reichenbach for *Mesopteryx* as used by Parker (*Trans. Zool. Soc.* 13), and it is desirable to note some difference between the skulls Parker described under *Mesopteryx* and the skulls of *Cela oweni*, *Cela curta*, and *C. geranoides*. They are the greater extent of the temporal fossae and their confluence with the lambdoidal ridges in *Cela*, which confluence however is due almost as much to the forward position of the lamb-

doidal ridge as the backward extension of the temporal fossa. The mamillar tuberosities are also more prominent in the above mentioned species. In the Auckland Museum there is a skull from Hikurangi which has the dimensions of *Mesopteryx* sp. a of Parker, but the form rather of his *Mesopteryx* sp. b, and the above mentioned differences are evident in a comparison of this Hikurangi skull with those of *C. curta*, *oweni* and *geranoides*. They may, however, be interspecific variations within the genus *Cela*.

The other portions of the skeleton are too abraded and fragmentary for description, which is especially unfortunate in respect to the sternum and pelvis.

I am much indebted to Dr. Chilton and Mr. Tonnoir for their help in discussing the nomenclature of this species.

B. In May last year Mr. R. T. Seccombe discovered a deposit of Moa bones in a fallen-in limestone cave at Karamu, about 15 miles from Frankton. Subsequently he brought them to Auckland for identification, and kindly presented them to the Auckland Museum.

Most of the bones were in a poor state of preservation, and many were broken or incomplete. Mr. Seccombe, however, most carefully recovered all the bones that were in the cave, and it is thus possible to state the number of individuals of the four species represented.

Of *Dinornis ingens* there are four right and two left femora, four right and four left tibiae, and the same number of right and left metatarsi; of these a pair of tibiae and of metatarsi are immature and another set of the same bones sub-immature. We therefore have four individuals represented, two adults, one sub-immature and one immature. The dimensions of the adult bones complete enough to measure are:—

<i>Tibiae.</i>		<i>Metatarsi.</i>	
Length	665—710 mm.	Length	360—375 mm.
Proximal width	145—160 „	Proximal width	94—100 „
Distal width	192—100 „	Distal width	18—130 „
Middle width	45—50 „	Middle width	41—44 „
Girth	130—142 „	Girth	115—125 „

*Dinornis novaezealandiae* Owen, which, as Rothschild (*Extinct Birds*, p. 194) pointed out is the correct name for the form commonly referred to as *D. struthioides*, is represented by only a tibia and a metatarsus. These two bones are in the same condition as with regard to fossilisation, and probably represent one individual.

The dimensions are:—

<i>Tibia.</i>		<i>Metatarsus.</i>	
Length	480 mm.	Length	255 mm.
Proximal width	105 „	Proximal width	70 „
Distal width	65 „	Distal width	85 „
Middle width	38 „	Middle width	33 „
Girth	99 „	Girth	88 „

There is some confusion with regard to the nomenclature of this species and of *D. ingens*. In *Proceedings Zoological Society* (1843), pp. 8 and 9, Owen described, under the name *Dinornis novaezealandiae*, a femur, a tibia-tarsus and a tarsometatarsus, in the order named. These bones were not those of an individual. The femur therefore is the type of the species. Owen subsequently renamed this species *D. struthioides*, but the rules do not allow this, so *D. struthioides* becomes a synonym of *D. novaezealandiae*. The tibiotarsus described by Owen with the femur and metatarsus under the name *D. novaezealandia*, is, however, too large for that species. Owen subsequently named it *D. ingens*. (*T.Z.S.* 3, p. 247, pl. 25, figs. 1 and 2 and pl. 26, figs. 1, 2 and 3.)

Lydekker however (*Cat. Foss. Birds*, p. 245) applied the name *D. struthioides* to Owen's type femur and the metatarsus described with it, and distinguished the tibia Owen had described with them as the type of *D. novaezealandia* (p. 224). He united with it *D. ingens* and *D. giganteus* as ♂ and ♀ respectively. This, as the foregoing shows, is wrong. Of the three bones originally described by Owen the femur is the type of *D. novaezealandia* (Owen); the metatarsus belongs to the same species, while the tibia is the type of *D. ingens* (Owen).

*Anomalornis didiformis* (Owen), seven individuals, is well represented, as might be expected, for it is a common species. Many of these bones, however, are much abraded, some are only fragments, and not one is complete enough to give measurements in every dimension.

The lengths of the adult tibiae are 325 and 342 mm., the middle width 26 to 28, and the girth 74 to 78; the metatarsi are 160—175 mm. long, middle width, 31—33, and girth 83—86 mm. A set of immature bones, and a set of a young bird probably represent individuals. Finally there are the right and left femora and two left tibiae, which I have referred to *Pachyornis pygmaeus*.

The dimensions are:—

	Length.	Proximal Width.	Distal Width.	Middle Width.	Girth.
Left femur	—	73.5	88	34	110
Right femur	195	—	91	34	110
Left tibia, complete	333	105	57	33	96
Left tibia, portion	—	—	—	33	86

The last is sub-immature.

These bones are on the small size for *P. pygmaeus*, but they are not as slender as *Cela geranoides*, and they are distinctly of the curved form, with much expanded extremities, of *P. pygmaeus*.

## Graptolites from Cape Providence, Chalky Inlet, Southland.

By ROBERT E. KEBLE.

(Communicated by Professor James Park.)

[Read before Otago Institute, 9th November, 1926; received by Editor, 27th November, 1926; issued separately, 13th August, 1927.]

IN 1922 graptolites were found by Professor James Park at Cape Providence, Chalky Inlet, Southland.\* The graptolites are preserved as a film on dark blue pyritic nodular slate, highly cleaved, and suggesting the close proximity of an antiline. Some specimens show detail, but the majority are indistinct and were cleared with difficulty when the occasion arose. In the collection is one new species and probably another. Owing to the fact that there was only one form of the second species in the collection it has been figured as *Didymograptus* sp.; the figure will be useful for comparison while searching for other specimens of the species.

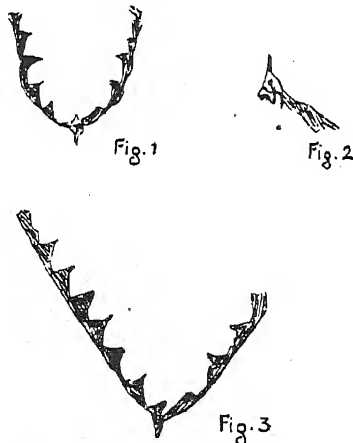


FIG. 1.—*Didymograptus bidens* n. sp. Polypary  $\times 4$ . Spec. 27.

FIG. 2.—*D. bidens* n. sp. Sicula and Theca  $1^2 \times 6$ . Spec. 4 (reverse of Type Spec. 27.)

FIG. 3.—*D. sp.* Polypary  $\times 4$ . Spec. 88.

### *Didymograptus bidens* n. sp.

*Description:* Branches arising suborally, gracefully curved for the first two thecae (Th  $1^1$ ,  $1^2$ ,  $2^1$  and  $2^2$ ), then divergent and lying within an angle of  $25^\circ$ . Minimum width near the sicula, under 0.2 mm.; maximum width 0.8 mm.; maximum length observed 5 mm.

Sicula about 1.7 mm. long.

Thecae 8 or 9 in 10 mm., about twice as long as broad and free for four-fifths of their length. Apertural margins straight or slightly convex, submucronate, inclined at an angle of approximately  $100^\circ$  to the axis of the branch. Ventral margin concave.

\*J. Park, "Discovery of Graptolites at Cape Providence, Southland." *N.Z. Journ. Sc. & Tech.*, vol. 5, p. 264, 1922.

*Remarks:* The polypary is slender in appearance. There is little doubt that the branches arise suborally slightly below the sicula aperture. In both *D. bidens* and its undescribed Australian equivalent, specimens frequently show the branches from different angles, suggesting that they may not have been in the same plane.

*Affinities:* *D. bidens* appears to be the first of a characteristic series of dependent *Didymograpti* to be described. I know of no other dependent form like it figured elsewhere. In Victoria there is, however, an undescribed closely allied form, with a similar insignificant thecal overlap and relatively wide submucronate thecae. It is found with the same associates as *D. bidens*.

*Didymograptus* sp.

Spec. 88 shows a form of *Didymograptus* which I cannot compare with any known form. The origin of the branches is apical; they are very slightly curved in the first thecae, then become straight and highly divergent, the normally compressed branch indicating an angle of  $110^\circ$ . Their maximum width is 0.8 mm.; minimum width under 0.2 mm.; maximum length observed about 8 mm.

The sicula is 1.5 mm. long and tapering.

Thecae 9 to 10 in 10 mm. less than twice as long as wide, free for three-quarters of their length. Apertural margin straight or slightly concave at an angle of  $105^\circ$  to the axis of the branch. Ventral margin slightly concave, inclined at an angle of  $45^\circ$ .

As there is only one example in the collection, I have refrained from elevating it to specific rank, preferring to await the discovery of others. The thecae are of the *D. bidens* type, but the origin of the branches is distinctly apical and the divergent angle considerable.

The New Zealand faunal province lying between that of Australia on the east, and America on the west, an interesting comparison is forthcoming by tabulating the species on a common basis.

	Species common to N. Zealand, Australia, and America.	Species common to N. Zealand and Australia.	Species restricted to N. Zealand.	Genera common to N. Zealand and Australia.
<i>D. bifidus</i>	+			
<i>D. extensus</i>	+			
<i>D. caducens</i>	+			
<i>T. pendens</i>	+			
<i>T. serra</i>	+			
<i>T. similis</i>	+			
<i>T. amii</i>	+			
<i>T. quadribrachiatus</i>	+			
<i>D. octobrachiatus</i>	+			
<i>D. procumbens</i>		+		
<i>D. adamantinus</i>		+		
<i>T. whitelawi</i>		+		
<i>D. bidens</i>			+	
<i>Clonograptus</i> sp.				+
<i>Goniograptus</i> sp.				+

Considering that *D. bidens* has its equivalent in Australia and that *D. procumbens*, *D. adamantinus* and *T. whitelawi* were hitherto regarded as restricted Australian forms, the similarity between the New Zealand and Australian fauna must be close. The Cape Providence beds could be accurately placed in the Australian Lower Ordovician, Castlemaine Zone, Subzone C4. Its Australian position is given to afford a means of checking the points of agreement and inevitable discrepancies between the two faunas. I have little doubt, however, that the points of agreement will be numerous.

## LIST OF SPECIES.

- Didymograptus bifidus* J. Hall. 7, 17, 21, 23, 25, 26, 30, 34, 36, 41, 46, 53, 60, 61, 62, 63, 64.  
*D. cf. bifidus*. 48, 61.  
*D. extensus* J. Hall. 1, 27, 72, 74, 79, 86.  
*D. cf. extensus*. 4, 11.  
*D. procumbens* T. S. Hall. 23, 26, 59, 60, 74.  
*D. cf. procumbens*. 28, 41, 65.  
*D. adamantinus* T. S. Hall. 26, 45, 54, 80.  
*D. cf. gracilis* Torn. 35.  
*D. caduceus* Salter. 3, 10, 12, 13, 14, 18, 19, 23, 25, 29, 32, 35, 38, 44, 60, 72, 74, 78, 79, 80, 81, 83, 85, 86.  
*D. cf. caduceus*. 16.  
*D. sp.* 11, 15, 16, 18, 20, 23, 34, 37, 46, 52, 58, 78, 84, 85.  
*D. sp. nov.* 4, 27, 88.  
*Tetragraptus pendens* Elles. 16 (?), 37 (?), 67 (?).  
*T. serra* Brong. 13, 15, 16, 33, 35, 46, 49, 54, 64, 69, 70, 77, 79.  
*T. cf. serra*. 10, 82, 85.  
*T. similis*, J. Hall. 37, 38, 57, 60, 70, 78, 79, 86.  
*T. amii* Elles & W. 19, 25, 55.  
*T. cf. amii*. 11.  
*T. whitelawi* T. S. Hall. 30, 57, 67.  
*T. cf. whitelawi*. 50.  
*T. quadribrachiatus* J. Hall. 30, 36.  
*T. cf. quadribrachiatus*. 36.  
*T. sp.* 61.  
*Dichograptus octobrachiatus* J. Hall. 11.  
*Clonograptus* sp. 33, 87.  
*Diplograptus* sp. 71 (?).  
*Phyllograptus cf. angustifolius* J. Hall. 31, 62, 73.  
*P. sp.* 8, 12, 38, 71, 73, 78, 86.  
*Goniograptus* sp. 54 (fragment).

## On the "Rodingite" of Nelson.

By L. I. GRANGE.

[Read, by permission of the Director of the N.Z. Geological Survey, before the Wellington Philosophical Society; received by Editor, 31st December, 1926; issued separately, 13th August, 1927.]

(Plate 20.)

COARSE-GRAINED gabbro-like dykes cutting the serpentine in the Dun Mountain Subdivision (north-east Nelson) have been described by several observers. Hochstetter (1864) called them saussurite-hypersthene rocks, and Davis (1871, p. 116) feldspar porphyry. Hutton (1866, p. 412) identified the minerals as anthophyllite and saussurite, and called the rock a corsite, but in 1889 (p. 146) said the identification of anthophyllite was an error, and termed the rock a saussurite gabbro (euphotide). Marshall\* (1911, p. 31) was the first to recognise their true mineral composition. He showed that some of these dykes consisted of grossularite and diallage, and gave to the rock the name "rodingite." Others made up of prehnite and diallage he called "prehnite rodingites," believing that the prehnite was a decomposition product of the grossularite. Possibly previous observers had closely examined only the prehnite-bearing rock.

There occurs also a fine-grained dense, white rock, referred to as Keiselschlierartigen by Hochstetter (1864), and as felstone and elvanite by Davis (1871, p. 116). Marshall (1911, p. 32) said this was really a fine-grained "rodingite" with only a small proportion of diallage.

Marshall thought that the grossularite-bearing rocks were primary, resulting from magmatic differentiation. He repeated this statement of their origin in an address (1925, p. 7) to the Cawthron Institute, Nelson, and remarked that his view was finally accepted by Rosenbusch. Finlayson (1909, p. 358) considered that the grossularite in the coarse dykes, and in the dense white rocks, had been formed by the digestion of limestone by the peridotite. The writer has evidence that the rocks containing diallage are really altered gabbros, the prehnite and grossularite being secondary after feldspar. The dense white rocks consist of grossularite and diopside, and are probably veins formed by solutions which have taken lime, magnesia and a little alumina from the pyroxene. These views are not original. As will be seen below, there are several references in the literature to similar rocks in other countries giving the inter-relation of their origin advanced by the writer.†

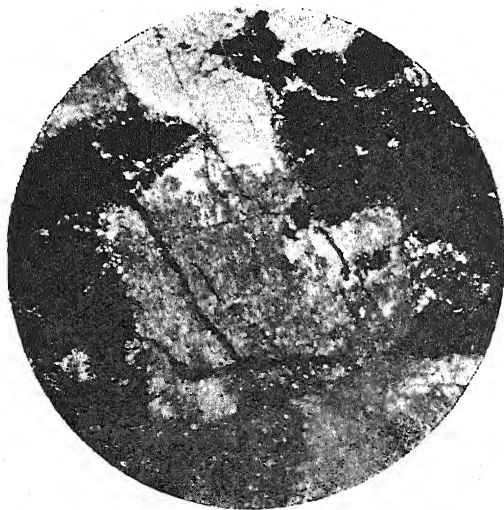
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\* Dr. Marshall wrote the chapter on igneous rocks in Bulletin No. 12.

† Dr. Arthur Holmes, of Durham University, writing on 9th October, 1926, states: "I have had a section cut of the specimen of rodingite you sent me, and I agree with you that the garnet is in all probability secondary after a calcid plagioclase."



1. Grossularite replacing and veining the diallage in garnetised gabbro, Coad's Point, Dun Mountain tram-line. Mag. 20 diam.



2. Grossularite veins in diallage in garnetised gabbro, Asbestos Claim, Takaka Valley. Mag. 20 diam.



These rocks have also been found by Mr. E. O. Macpherson and the writer, in the Red Hills and in the south-west branch of the Wairoa River (Gordon Survey District) lying to the south-west of the Dun Mountain, and in the upper Takaka Valley, West Nelson, during the survey of the Motueka Subdivision. Among the erratic boulders collected by Mr. H. Hamilton, of the Dominion Museum, on Macquarie Island, during the Australasian Antarctic Expedition, in 1913, are gabbros containing prehnite.

A complex sill of basic and ultrabasic rock intrudes the Maitai (Permian) and Te Anau (Devonian?) argillites greywackes, and conglomerates in the Dun Mountain Subdivision (Geological Survey Bulletin, No. 12), in the Wairoa River, and in the Red Hills at the head of the branch of the Motueka River, flowing south from Mount Rufus. Northward, they have been traced as far as D'Urville Island. These localities are on the northern end of the main mountain-axis of the South Island.

At Dun Mountain, and in the Red Hills, there is a central area of dunite and a border of serpentinized harzburgites, wehrlites, pyroxenites, and dunites traversed by numerous dykes and veins of altered gabbro and diorite, and veins of the grossularite diopside rock. In the upper Takaka Valley there is an area of about six square miles formed of bastite serpentine and a little serpentinized dunite, with a wide border of gabbro and diorite. The central area is traversed by a granite dyke and a few thin dykes of garnetised gabbro.

The prehnite rodingite of Marshall is made up of pyroxene and an aggregate in which prehnite and zoisite can be distinguished. It occurs in fine- and coarse-grained gabbros. The change from a slightly saussuritized gabbro to one in which the feldspar is entirely replaced by the prehnite-zoisite aggregate can be clearly traced under the microscope. The material here called saussurite is a dense dirty-brown irresolvable mixture. Ordinary saussurite is an aggregate consisting largely of zoisite, with more or less albite, and occasionally garnet, together with tremolite, chlorite, and rarely scapolite, etc.

The least altered gabbros are, as a rule, fine-grained. One (Spec. No. 134) from the head of the branch of the Motueka, flowing south from Mount Rufus, contains colourless augite, feldspar, serpentine, and ilmenite. The feldspar (oligoclase) is fractured and bent, and the ilmenite is partly altered to leucoxene. Some of the plagioclase in a gabbro (Spec. 104) from the Wairoa River, six miles above the junction with the south-east branch, is completely altered to “saussurite.” A specimen (No. 283, No. P. 1574 of table of analyses) from a branch of the Motueka River, three miles west of Ellis Trig. station has the augite altered to greenish-brown hornblende of irregular outline. The feldspar is fresh, and titanite or sphene occurs as an accessory mineral.

A more altered gabbro (Spec. No. 32) comes from a small branch of the Motueka River four miles west-north-west of Red Hill Trig. Station. The plagioclase is altered to “saussurite” with patches of the prehnite aggregate. The augite has changed to green hornblende and ilmenite is partly replaced by leucoxene. In a further stage the prehnite-zoisite aggregate entirely replaces the feldspar. This is

well seen in section D 13a from a boulder in the Roding River, where the outline of the feldspar crystals is still visible. The other minerals are diallage and enstatite, now altered in part to bastite. In sections 123 and 128 from the Wairoa River, two miles and a-half north-north-west of Mount Ellis, the feldspar cleavage can be made out in the fine-grained aggregate. The ferromagnesian minerals are interlocking diallage and brown hornblende. No. Q 2071 is an analysis of the aggregate from the Wairoa River (Spec. No. 106). It agrees closely in composition (Q 3310a) with that in the altered gabbro from Macquarie Island. Here the ferromagnesian minerals are diallage and hornblende as in section 123. Q 3310 is an analysis of the rock. A gabbro (Spec. 12) from the Motueka Valley, one mile and a quarter south-south-east of Mount Glennie, of which No. Q 3308 is an analysis consists of diallage altered to tremolite and antigorite, the remainder being an aggregate in which prehnite can be distinguished. The aggregate shows traces of the feldspar cleavage.

In the rock (Spec. D 20) from the track up Hacket Creek, one mile below Goat Creek junction (Aniseed Valley) zoisite and prehnite can be distinguished. The diallage is serpentized in part. Section 113 from the Wairoa River contains diallage with the cleavage planes twisted and in part altered to tremolite and an aggregate of prehnite and zoisite. In other sections, for example those of the rock from the track two chains below the Champion Mine (Aniseed Valley), only zoisite can be recognised as an alteration product of the feldspar.

The garnetized gabbros vary widely in texture, the pyroxene crystals ranging in length from a fraction of a cm. to about 8 cms. The coarse rocks, which are probably veins, are much more common. The grossularite has a light green colour, and under the microscope is either colourless or light brown.

Direct evidence that the grossularite forms from feldspar is wanting. There is, however, the fact that in a hand specimen (No. 106) of the coarse rock from the Wairoa River the prehnite aggregate is associated with garnet (S.G. 3.438). But there is good evidence in several of the sections that the grossularite is secondary. In a band 2 inches wide in the serpentine on the west side of the branch of the Motueka River, flowing south from Mount Rufus, the grossularite enters the diallage occasionally as narrow veins. Sections of thin dykes of altered gabbro at the head of the Wairoa River, east of Mount Glennie (Spec. 129), and also from lower downstream, show in several parts the garnet eating into and isolating small areas of the diallage. Q 3306 is an analysis of a grossularite-diallage rock outcropping near the upper Motueka River, one mile and a half south of Mount Harvey (Gordon Survey District), in which the diallage is the more abundant material. The rock from Coad's Point (D 1A, fig. 1) on the Dun Mountain tramline shows the grossularite replacing and veining the diallage. The garnet of this specimen contains crystals of zoisite and diopside. Grossularite veins are seen in section 259 (Fig. 2) from the Asbestos Claim, upper Takaka River. The pyroxene of D 5 from Champion Creek is now altered to chlorite and serpentine, and garnet has penetrated along the cracks. As specimen from the same locality as D 1A shows roundish areas of serpentine, probably formed from pyroxene, a colourless

cavernous mineral with vitreous lustre and a light brown mineral. Under the microscope the colourless mineral is seen to be zoisite and the brown to be grossularite, crowded in parts with long thin needles of diopside. Veins of grossularite cut across the serpentine.

Radical chemical changes are involved in the alterations described above. To produce grossularite and prehnite from the anorthite of feldspar, lime and silica, and, in the case of the prehnite, aggregate water must be added if the alumina is to be kept constant. According to Graham (1917, p. 166) when diallage is serpentinized the following reaction takes place:— $3\text{Ca Mg Si}_2\text{O}_6 + 2\text{H}_2\text{O} \rightarrow \text{H}_4\text{Mg}_3\text{Si}_2\text{O}_9 + 3\text{Ca SiO}_3 + \text{SiO}_2$ .

Thus it appears that the alteration of diallage will supply the lime and silica needed for the conversion of feldspar to garnet and prehnite. During this change the albite in the feldspar will be set free. Secondary albite crystals 0.5 cm. in length line a rug in gabbro close to Hacket Creek, one mile below the point where it is joined by Goat Creek. Alongside is a vein, 3 feet wide, of secondary albite. In other cases the albite is altered to pectolite (see Weinschenk, 1912, p. 300). This mineral (analysis No. P 1599) has been found in small veins cutting altered gabbro in the Wairoa River.

Murgoci and Benson have described gabbros now containing prehnite and grossularite. Benson (1918, p. 722) summarises thus the former's work (1900): “Murgoci found included in the Paringu (Roumania) serpentine, masses of diopside, diallage, with grossularite, vesuvianite, fassaite, clinozoisite, lotrite (a form of prehnite), clinocllore, apatite, ilmenite, rutile and sphene. He concluded that the more coarsely granulitic masses, with an appearance like that of saussurite-gabbro, were indeed an altered form of gabbro, but that some hornstones of similar mineral composition were altered inclusions of chloritic calc-schist.” Benson (1914, p. 682) considered that the prehnite and grossularite of the gabbros of the Great Serpentine Belt of New South Wales were secondary after feldspar. Having examined some of Dr. Marshall's material from the Dun Mountain Subdivision he concluded (1914, p. 687) that there also these minerals were secondary, but could not “suggest how they had become so altered.”

The dense white rock, previously mentioned (fine-grained “*rodingite*” of Marshall), occurs as veins or lenticular masses, and is often much slickensided. It is made up of grossularite and needles and tabular crystals of diopside. The rock from the saddle between the Maitai and Roding Rivers, and at Champion Mine, Aniseed Valley, contains also irregular areas of a mineral with a sulphur-yellow colour which under the microscope are seen to be vesuvianite. Two “boulders” of serpentine in the Asbestos Claim of Upper Takaka Valley, show the manner in which this garnet-bearing rock has been formed. The pyroxenites were divided into cuboidal masses, along which solutions penetrated and gradually serpentinized the masses to the centre. They now appear as rounded “boulders,” much like those left by spheroidal weathering. The cores of two boulders are formed of irregular masses of a white rock. Thin sections of the white rock taken from the contact with the serpentine show serpentinized diallage cut by veins of grossularite containing diopside. Evidently

in penetrating to the centre the solutions have gathered lime, magnesia and a little alumina from the pyroxenes to form these secondary minerals high in calcium. A somewhat similar origin has been ascribed by Graham (1917, pp. 174-76) to grossularite, diopside, and vesuvianite veins in serpentine in Quebec.

The writer is indebted to the Director of the Geological Survey for suggestions and facilities in the preparation of this paper. Dr. Benson kindly lent the writer his slides of the altered gabbros of the Great Serpentine Belt of New South Wales, and examined many of the slides that have been described above. He agreed in the main with the writer's interpretations, and pointed out some of the errors he had made. Through the courtesy of Professor Easterfield, of the Cawthron Institute, the writer was able to look at the sections made by the late Mr. W. F. Worley. The excellent microphotographs reproduced in Figs. 1 and 2 were made by Mr. W. C. Davies, of the Cawthron Institute.

- P 1574. Gabbro, branch of Motueka River, three miles west of Ellis Trig. Station, Gordon Survey District. Analyst, F. T. Seelye, Dominion Laboratory.
- Q 2071. Prehnite-zoisite aggregate in altered gabbro, south-west branch of Wairoa River, Gordon Survey District. Analyst, F. T. Seelye.
- Q 2069. Diallage in gabbro, south-west branch of Wairoa River. Analyst, F. T. Seelye.
- Q 3308. Gabbro with prehnite-zoisite aggregate, Motueka Valley, one mile and a quarter south-south-east of Mount Glennie, Gordon Survey District. Analyst, F. T. Seelye.
- Q 3310a. Prehnite-zoisite aggregate in altered gabbro, Macquarie Island. Analyst, F. T. Seelye.
- Q 3310b. Diallage in altered gabbro, Macquarie Island. Analyst, F. T. Seelye.
- Q 3311. Gabbro with prehnite-zoisite aggregate, Macquarie Island. Analyst, F. T. Seelye.
- Q 3306. Garnetised gabbro, one mile and a half south of Mount Harvey, Upper Motueka Valley, Gordon Survey District. Analyst, F. T. Seelye.
2209. Grossularite, Roding River, Dun Mountain Subdivision (N.Z. Geol. Surv. Bull. No. 12, p. 32, 1911). Analysed in Dominion Laboratory.
- 2209 and 2212. "Rodingite" calculated from  $\frac{2}{3}$  grossularite (2209) and  $\frac{1}{3}$  diallage (2212) from Long Gully, Lee River, Dun Mountain Subdivision (N.Z. Geol. Surv. Bull. No. 12, p. 32, 1911).
- P 1572. Dense white grossularite-diopside rock, half a mile south-south-east of Cairn at 2602 feet,  $1\frac{1}{2}$  m. south of Mount Glennie, Motueka River Valley, Gordon Survey District. Analyst, F. T. Seelye.
- Q 3307. Dense white grossularite-diopside rock, near head of Motueka River, Gordon Survey District. Analyst, F. T. Seelye.
- P 1599. Pectolite, mouth of branch of Wairoa River, 130 chains north-north-east of Mount Glennie. Gordon Survey District. Analyst, F. T. Seelye.

	P1574	Q2071	Q2069	Q3308	Q3310a	Q3310b	Q3311	Q3306	2209	2212	P1572	Q3307	P1599
Silica (SiO <sub>2</sub> )	52.48	38.68	46.45	43.99	41.98	48.97	43.04	40.73	36.05	40.75	38.10	40.40	53.77
Alumina (Al <sub>2</sub> O <sub>3</sub> )	18.12	27.52	5.46	18.17	23.99	4.96	15.61	11.48	25.79	17.64	7.86	14.89	0.46
Ferric oxide (Fe <sub>2</sub> O <sub>3</sub> )	1.01	0.20	0.63	0.59	0.31	0.53	0.67	3.24	nil	0.96	11.36	2.19	none
Ferrous oxide (FeO)	7.08	0.63	6.44	2.97	0.74	4.74	4.99	3.35	0.56	1.46	0.69	3.20	0.07
Magnesia (MgO)	3.80	1.46	23.48	9.82	1.63	17.24	9.14	12.62	0.15	6.09	6.20	5.45	1.00
Lime (CaO)	7.85	24.86	10.93	18.11	24.40	20.24	19.99	23.60	35.72	31.22	30.81	31.16	32.38
Soda (Na <sub>2</sub> O)	5.74	0.80	0.16	1.04	0.84	0.27	0.17	0.12	0.13	0.12	0.03	0.09	8.74
Potash (K <sub>2</sub> O)	0.14	0.57	0.13	0.26	0.76	none	none	none	0.13	0.12	none	none	0.11
Water lost above 105°C	2.33	4.59	5.33	4.29	4.92	1.93	4.70	4.04	1.10	1.36	2.30	2.10	3.02
Water lost below 105°C	0.20	0.36	0.86	0.29	0.23	0.18	0.45	0.26	nil		0.49	0.11	0.43
Carbon dioxide (CO <sub>2</sub> )	0.03	0.24	trace	0.06	0.18	0.03	0.20	0.11	nil		0.18	0.18	0.13
Titanium dioxide (TiO <sub>2</sub> )	0.76	none	0.11	0.12	0.07	0.51	0.43	0.44	0.03	0.04	1.76	0.24	none
Zirconium dioxide (ZrO <sub>2</sub> )	none	none	none	none	none	none	none	none	none	none	none	none	none
Phosphorus pentoxide (P <sub>2</sub> O <sub>5</sub> )	0.22	0.03	0.10	0.02	trace	none	none	0.03			0.17	0.04	none
Sulphur (S)	trace	trace	trace	trace	0.04	0.01	0.01	0.02			0.02	none	trace
Chromium oxide (Cr <sub>2</sub> O <sub>3</sub> )	trace	none	0.12	0.11	none	0.20	none	0.10	nil	0.08	0.02	none	
Nickel oxide (NiO)	0.01	trace	0.08	0.02	trace	0.07	0.04	0.05			0.01	trace	
Manganese oxide (MnO)	0.13	0.03	0.09	0.67	0.04	0.18	0.32	0.11	0.15	0.28	0.17	0.15	0.02
Strontia (SrO)	0.03	0.18	none	none	0.05	none	none	none			none	none	none
Baryta (BaO)	none	trace	none	none	0.04	none	none	none			none	none	none
	99.93	100.15	100.37	99.93	100.22	100.06	99.76	100.30	99.68	100.00	100.17	100.20	100.07

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## Food Values of New Zealand Fish.

### Part 8.—Stewart Island Oysters.

By JOHN MALCOLM, M.D.

[Read before the Otago Institute, 14th December, 1926;  
received by Editor, 31st December, 1926; issued separately,  
15th August, 1927.]

ANALYSES of these oysters made in 1911 by the present writer yielded figures for protein, fat, glycogen, and salts, that did not greatly differ from those obtained by workers in other parts of the world. Since then, however, new views as to the nutritive value of foodstuffs have been put forward, and it seemed desirable to investigate the vitamin-A content of the oyster, and to make some preliminary observations on the nature of its nitrogenous substances.

#### *Vitamin.*

Only vitamin-A was investigated. Quite recently an abstract of a paper by Jones and Murphy (1) has appeared in which oysters, probably American, are reported to be rich in Vitamins A and B. According to Mme. Randoin (2) vitamin C is also present.

*Method:* Rats were kept from the time of weaning on a basal diet containing casein, starch, fat, vitamin B ("Marmite"), and salts. The fat used in the earlier experiments was well aerated lard, in the later, "Crisco" with the addition of aerated cod-liver oil; in each case the antirachitic factor "D" may be presumed to be present.

In Paper 6 of this series (3) some preliminary experiments on oyster fat were reported. The fat, obtained by alcohol and subsequent extraction with ether, showed no activity, and seemed actually harmful. In the case of fish (tarakihi) investigated last year, good results were obtained by incorporating the fresh material with casein, starch, fat, etc., in such proportions that the composition of the mixture corresponded to that of the basal diet. When this was done with fresh oysters it was soon made clear that they contained vitamin-A.

*Experiments 1—3* were made on a quantity of oysters procured from a fishmonger in June. They were drained, minced, weighed, and analyzed for fat and water percentage. They seem to have been of rather poor quality, for the average weight per oyster was only 7 gm. as compared to the usual 10–12 gm. The fat was low (1.9 per cent.) and the water high (80 per cent.), and the results of feeding were not so striking as were obtained with the later samples.

*Experiment 1:* Three sister rats (Litter Ad. 5) on basal diet showed decline of weight and slight eye symptoms about the eighth week after weaning. One died and the two survivors were put on a fresh oyster diet that would allow each 5.0 to 6.0 gm. oyster per day, assuming that each rat ate 8 to 10 gm. of the whole diet with which the oyster mince was incorporated. In the 12 days during which this diet was given the eye symptoms disappeared and their weight increased from an average of 71 gm. to an average of 89.

On returning to basal diet the rise continued till they reached about 95 gm., and for five weeks after the special diet ceased their weights were maintained at about the 90 gm. level. Then eye troubles recurred. One died and the other was used for preliminary experiments on another substance. The growth curves of this and of the other experiments are shown on Charts 1 and 2.

*Experiment 2:* A buck rat (Ad. 2, No. 1) of the same litter developed marked photophobia with loss of weight ten weeks after weaning. His brother, on the same diet, had died with marked eye symptoms about the eighth week. He was given a diet containing the whole fat obtained by percolation from the same weight of oyster as was used to make up the diet used in Exp. 1. The method adopted here was to mix the fresh oyster mince with sufficient Plaster of Paris to make it set hard in about 24 hours; the mass was then broken up finely and placed in an inverted glass bottle from which the bottom had been removed. Ether was allowed to pass down through the powder and escape with the dissolved fat from the neck which was provided with a cork and tube. Percolation was continued for one or two days till no more colour appeared in the ether. The ether was removed by distillation and the residue used for the diet. Immediate improvement set in, but the gain in weight was not maximal and was less prolonged than in Exp. 1. But it gave clear proof that the percolation method had extracted some of the vitamin. The amount of percolated fat consumed per day would be about 0.1 gm.

*Experiment 3:* Some of the same oyster material (June lot) was dried in a regulated oven at 52° C. for two days. The "fat" was extracted by the Soxhlet method, and both fat and residue made into diets similar to those used in Exp. 1 except that in one diet the "fat" replaced a corresponding amount of "Crisco," and in the other diet the "residue" replaced a certain calculated amount of protein, carbohydrate, etc. These diets were given in succession to a doe rat (Ac, 2, No. 2). She was one of a group of three sisters; two had developed eye symptoms and had died 7 and 8 weeks after weaning. The survivor at 9 weeks had ceased to grow, and the eyes were apparently beginning to be affected. She was first given a diet containing Soxhlet fat. Little or no improvement resulted in the 12 days during which she received the diet, but on changing it to the "residue" diet a distinct increase was obtained.

Unfortunately, as stated already, this batch of June oysters was not so rich in vitamin-A as had been expected, and the level of intake of vitamin in these three experiments was low, but Experiment 3 shows that in the process of drying the vitamin becomes less soluble in ether—so that now the residue contains more vitamin than the extracted fat.

*Experiment 4:* On August 11 another quantity of oysters was obtained. Some of the material was dried overnight in the oven and extracted with ether (Soxhlet method). The "fat" and "residue" were then combined in one diet corresponding in general composition to basal diet, the object being to see whether material so treated could give a maximal effect. The amount of oyster used was much greater than what was used in Exps. 1—3, and was probably much more than was necessary. Two bucks (Ah, 3 Nos. 1 and 2) developed eye

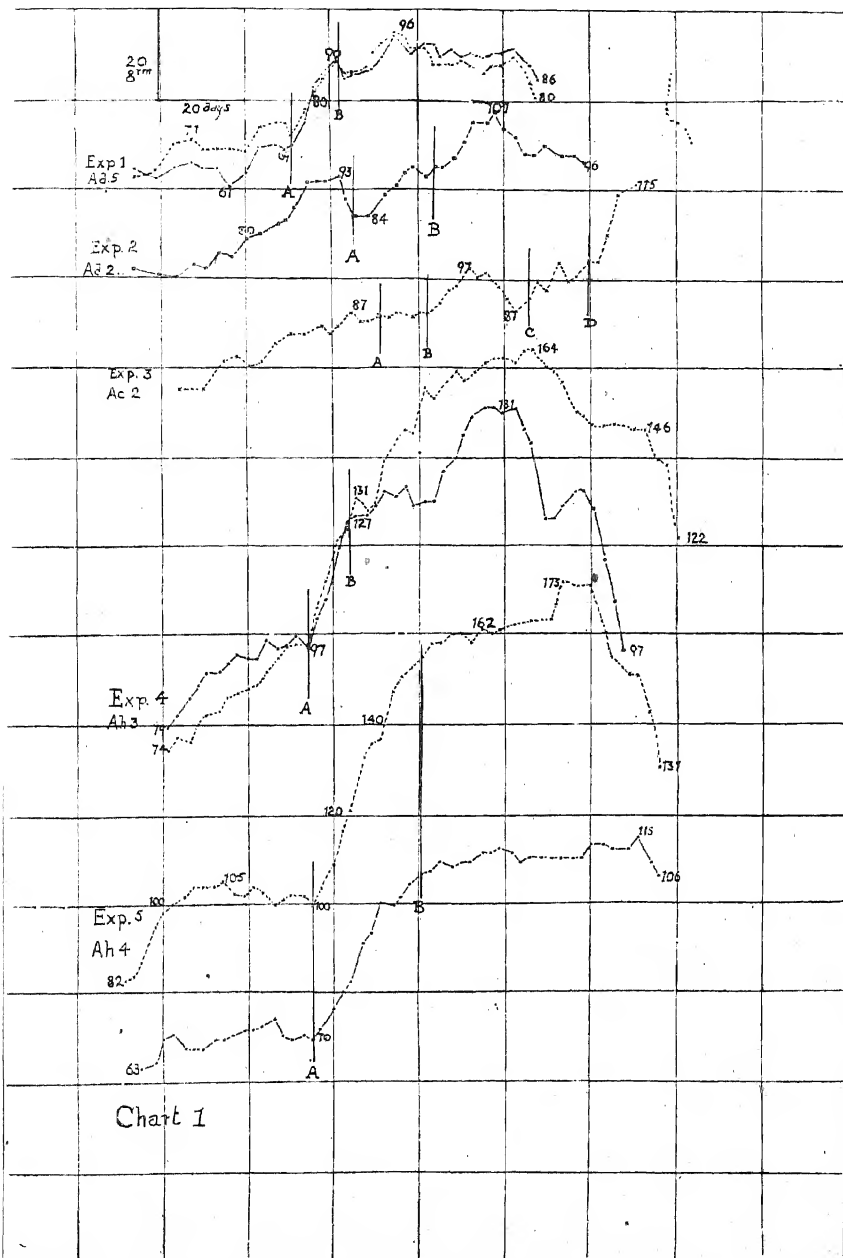


Chart 1

- Exp. 1. From A to B, fresh oyster incorporated with the diet.  
 Exp. 2. From A to B, percolated oyster fat given.  
 Exp. 3. At A, oyster fat (Soxhlet); at B, residue of same; at C, basal diet resumed; at D, cod liver oil.  
 Exp. 4. From A to B, oyster fat (Soxhlet) + residue simultaneously. Dose was larger than necessary.  
 Exp. 5. From A to B, equivalent of 1 gram. fresh oyster per rat, given separately. The oysters used were non-spawning.

symptoms and began to lose weight 8 weeks after weaning. On administering the oyster diet an immediate rise in weight set in, and within a week no trace of eye trouble could be detected. The diet was continued for 10 days, but on returning to the basal diet the beneficial result remained for 7 weeks; then one developed a lump in the neck and both had recurrence of eye symptoms and loss of weight. No. 1 died at 9 weeks and No. 2 at 11 weeks after the oyster diet had been discontinued. The amount of oyster per rat per day may be stated thus:—342 grm. fresh oyster yielded 6.72 grm. fat (1.96 per cent.) and 58 grm. residue (probably not quite water-free). These were made up into a diet containing about 214 grm. solids—the proportion of proteins was probably a little higher than the 20 per cent. usually present in basal diet. When the amount of water used in making up the diet is taken into account the amount of fresh oyster per day works out at 10 to 12 grm. on the assumption that the rat ate 10 grm. of the diet per day.

*Experiments 5 and 6:* A third quantity of oysters was obtained on October 12. They were in two lots; some were considered edible by the fishmonger, and others, spawning, would not have been sold in the ordinary course of events. These were larger oysters than the June ones (the August samples were not counted and weighed). The average weight of the unspawned was 10 grm., that of the spawning, 8 grm. 200 grm. of each kind was made into a diet corresponding to the basal diet in the proportions of protein, etc.

*Experiment 5:* The rats in this case were offered a certain amount of the diet (3 grm. for the two) corresponding to 1 grm. of fresh non-spawning oyster for each rat in a separate dish. Along with this they received basal diet. Usually the oyster diet was eaten greedily, and was no doubt supplemented by the basal diet. The previous history of the two rats (Ah, 4, 2 and 3) was practically the same as the others of this litter (e.g. Ah, 3). Immediately after beginning the diet their weight rose rapidly, and the eye symptoms gradually disappeared. The diet was continued for three weeks during which the weights increased from 100 grm. to 150 grm. and from 70 grm. to 110 grm. After stopping the diet one continued to grow for six weeks, and reached a weight of 173 grm., the other remained at about 110 grm. for a slightly longer time. At the time of writing both are losing weight steadily and both have eye symptoms. This is the best result obtained with oysters so far; and is a clear proof that the vitamin-A content was high in this batch of oysters: for the 1 grm. of fresh material would not contain more than 0.25 grm. solids and the fat would not be more than 30 milligram.

*Experiment 6:* The "spawning" oyster material was similarly prepared and administered in a separate dish to a doe (Ah 2, No. 2), but the diet when made was less concentrated than the other and in order to obtain the same amount of oyster the rat had to eat a larger quantity, viz., 3 grm. She was offered 7 grm. daily because at the time of commencing the diet it was uncertain how much would be required for either group. Almost from the first dose of oyster diet her weight began to rise, and it continued to rise rapidly in the three weeks during which the diet was given; she did not always consume the full ration of oyster diet. About three weeks after the return to

basal diet the weight began to drop. A striking feature of the experiment was the persistence of the eye symptoms throughout the six weeks of rising weight. Although the quantity given here was larger than in Experiment 5, the good effect lasted only for three weeks against six weeks for the others, so that, one can be tolerably certain that "spawning" or "spawned" oyster has less vitamin-A. This is also supported by the result of the next two experiments.

*Experiments 7 and 8:* The fourth batch of oysters was obtained on October 30, very near the end of the oyster season in New Zealand, and the fishmonger had no difficulty in supplying some that were spawning as well as some that were considered edible. On draining the former through cheese cloth, a milky-looking fluid containing spawn passed through—this was also seen in the other case, but much less marked. Diets were made with each kind of material, and given in the same way as in the last mentioned experiment. The rats used were two groups of two each belonging to the same litter (Ak.). They had begun to decline in weight, but had no observable eye symptoms. The amounts given were the equivalents of 1 gr. fresh oyster per rat per day. The result on growth was not so striking as in Experiments 5 and 6, but there was a distinct difference between those receiving the "non-spawning" oyster as compared to the "spawning." The former increased in weight during the time of administration (3 weeks), and continued to grow for at least a fortnight longer, while the others showed little increase in one and a very irregular curve in the other; on stopping the diet both began to decline and to show eye symptoms. At the time of writing one of these is dead and the other is steadily losing weight, while the two on non-spawning oyster continue to grow.

#### *Analytical Data.*

Although no attempt at complete analysis of these oysters was made, in order to make up diets correctly it was necessary to know the approximate percentage of fat and water. Some nitrogen estimations were also made. These data are presented here in Tables 1 and 2.

*Table 1.*

Date	Average weight per oyster.	Fat percentage	Glycogen percentage	Remarks.
Aug. 1924	10 grm.	2.58	—	
June, 1925	7 grm.	1.90	—	
Aug., 1925	?	1.96	—	
Oct. 12, 1925	10 grm.	—	2.6	non-spawning
Oct. 12, 1925	8 grm.	—	2.2	spawning
Oct. 31, 1925	9.5 grm.	2.44	4.1	non-spawning
Oct. 31, 1925	6.4 grm.	1.57	1.6	spawning

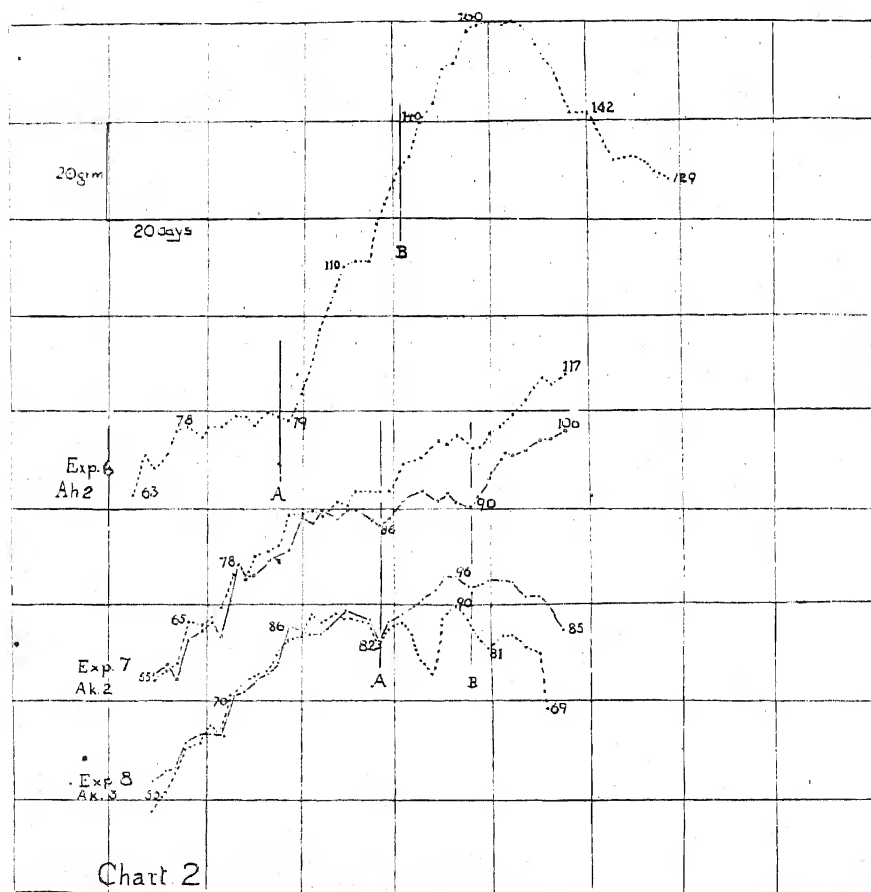
*Table 2.*

Nitrogen in Oysters of October 31st.

	Non-spawning.	Spawning.
In form of protein ....	1.60%	1.53%
In extractive form ....	0.69%	0.52%
	<hr/> 2.29%	<hr/> 2.05%

It may be noted that the fat in these oysters was lower than that previously reported in 1911 and less than the estimation made in 1924. The glycogen and fat of the fourth batch of oysters was higher than the others, which may be due to the fact that they were from new ground. While these variations may be expected when the oysters are not dredged from one special area, and when no note of age is taken, one feature of the analysis is a striking one, viz., the difference between the "non-spawning," and the "spawning" or "spawned." This difference is seen in the average weight per oyster, the fat and the glycogen, while we have just shown that the spawned oyster has less vitamin-A.

A large proportion of the nitrogen of the oyster is present in non-protein form and this is probably the case in all shell fish for the



Exp. 6. From A to B, equivalent of more than 1 grm. fresh oyster (spawning or spawned) given separately.—Compare to Exp. 5.

Exps. 7, 8. From A to B, equivalent of 1 grm. fresh oyster per rat daily.

Ak. 2 (upper) received non-spawning oyster.

Ak. 3 (lower) received spawning or spawned oyster.

same result in nearly the same relative proportion was found in the paua as reported Paper 4 of this series. The method of distinguishing the two forms of nitrogen was as follows:—10 grm. fresh oyster had added to it 40 cc. water and the whole brought to boiling point. 150 cc. of 98 per cent. alcohol was then added and the mixture allowed to stand for a day at room temperature, then filtered, washed with alcohol, and nitrogen estimation made in both residue (protein) and filtrate plus washings (extractives).

### *Summary and Conclusions.*

1. The oysters examined varied to a considerable extent, due probably to food, age, season and condition, but all showed presence of vitamin-A as tested on rats that were supplied with the antirachitic factor. In one experiment (5) it was found that a diet containing so little as 1 grm. fresh oyster produced maximal growth and probably maximal storage. In another (7) the same quantity produced submaximal but considerable effects, while 5 to 6 grm. (calculated intake Exp. 1) in another batch of oysters failed to produce maximal growth.

2. Dried oysters also produced effects in doses that were equivalent to larger doses than those used for fresh, e.g., in Exp. 4, where the equivalent was probably about 10 grm. fresh oyster, growth was maximal.

3. The method of dehydration of the food material by Plaster of Paris followed by ether percolation gave much better results than ordinary drying of the material followed by Soxhlet extraction with ether. In one experiment (3) there was more vitamin effect obtained with the residue than with the Soxhlet extract.

4. There is a distinct loss of food value of the oyster in the process of spawning. The average weight, the fat, the glycogen, and the vitamin-A content are all diminished.

5. The proportion of the total nitrogen that exists in the non-protein form in the oyster is relatively large.

The writer begs to acknowledge with thanks the financial aid of a grant from the New Zealand Institute, without which the research would have been impossible; also thanks are due to Miss Earland for her services in looking after the rats, and to Mr. N. Edson for help in the analytical part of the work.

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## Estimation of Carbon by Wet Combustion.

By H. O. ASKEW.

[Read before Philosophical Institute of Canterbury, 1st September, 1926;  
received by Editor, 31st December, 1926; issued separately,  
15th August, 1927.]

THIS paper is a short account of work done when in search of a method for the accurate estimation of small quantities of alcohol; it is followed by a short list of references to wet combustion methods.

The wet oxidation methods have been used for a variety of purposes, from the estimation of carbon in steel to the estimation of organic matter in soils and agricultural products. Many modifications of these methods are to be found in the literature, the variations being often developed to prevent the spray or mist which is formed during the reaction from being carried over into the absorbent for the carbon dioxide.

The methods may be divided into two classes; first, those in which the carbon is completely oxidised to carbon dioxide, this being absorbed, after washing and drying, in standard alkali, or in weighed soda-lime or potash tubes; and, second, those in which standard solutions of potassium di-chromate, etc., are used, the excess of oxidizing agent being estimated by suitable means.

### *Class 1.*

The apparatus used in the experiments described below was a modification of that used by Hibbard (4) which is in turn modified from that of Truog (10). The oxidation was carried out in a 250 c.c. hard glass round-bottomed flask, the neck of which had been ground to fit a large hard glass condenser, the distance between the neck of the flask and the bottom of the water-jacket being about four inches. Into the top of the condenser was fitted a double-bored rubber stopper, one hole to admit the reagents and pure air, the other to carry the outlet tube to the train of drying tubes, etc. The reagent was admitted drop by drop, first the chromic solution and then the acid, through a tube which reached below the level of the mixture in the reaction vessel, while a slow stream of carbon dioxide-free air was drawn through the apparatus. The gas evolved was purified and dried through a U-tube containing pure granulated zinc, two bubblers containing concentrated sulphuric acid, and finally through two U-tubes with fresh calcium chloride. A U-tube containing soda-lime was used to absorb the carbon dioxide; between this tube and the filter-pump a calcium chloride guard tube was placed.

To carry out an experiment a known volume of liquid containing the carbon compound in dilute solution is placed in the reaction vessel and a slow stream of air drawn through. Then the reagent is slowly admitted, all the time warming the flask with a small flame. The liquid darkens and becomes almost black; small bubbles of carbon dioxide soon begin to rise through the liquid, when the

heating is moderated until the reaction is nearly finished, after which the liquid is boiled for twenty minutes. An experiment can be completed in an hour.

When concentrated sulphuric acid is used in the oxidizing mixture a thick fog forms and passes into the U-tubes, but passage of the gas through constant boiling point acid is said to remove the mist particles (11). If phosphoric acid (sp. gr. 1.75) is used this fog does not form; moreover the liquid does not darken to the same extent as with sulphuric acid.

The oxidizing solution is made up as follows: 170 g. of pure chromic oxide are dissolved in 300 c.c. of distilled water to which 25 c.c. of concentrated sulphuric acid are added, the whole being then boiled to oxidize any organic matter which may be present. When cold the solution is made up to 500 c.c. with water (4).

A quantity of the compound is taken such that 0.10 to 0.15 g. of carbon is present. In general 15 c.c. of the chromic solution and 25 c.c. of sulphuric (or phosphoric) acid are used for oxidation; about 100 c.c. of carbon dioxide-free water are used for dilution in the reaction vessel.

With solid materials this method gave good results, especially with a comparatively easily oxidized substance like oxalic acid. With alcoholic solutions, however, the results were hopeless; oxidation proceeded practically only as far as aldehyde, this being absorbed in the sulphuric acid bubblers, while a small quantity of carbon dioxide was formed and absorbed in the soda-lime tube. Even when the vapour leaving the reaction vessel was passed through a hot tube containing palladiumized asbestos, the results were very little better. Oxygen from a cylinder was also used instead of air, but even in this case no useful results could be obtained.

Two standard solutions were made up: (1) saccharose, 1 g. in 200 c.c. of carbon dioxide-free water, and (2) oxalic acid 2 g. in 200 c.c. of water. In table 1 are given some of the data obtained; with oxalic acid phosphoric acid was used in place of sulphuric acid.

*Table 1.*

Compound	Oxidizing solution c.c.		Carbon dioxide mg.	
	Chromic	Acid	Found	Theory
Saccharose	15	25	185.0	191.5
Saccharose	25	25	188.4	191.5
Oxalic Acid	15	25	173.3	173.2
Oxalic Acid	15	25	173.4	173.2

In the analysis of organic compounds containing halogens a slightly different procedure is necessary owing to the evolution of the halogen either free or in combination with chromium; Robertson (5, 6, 7) has worked out the methods for such cases.

#### *Class 2.*

Both potassium dichromate and potassium permanganate have been used for the oxidation of alcohol, being of particular use for

the estimation of small quantities. In the present work neither of the permanganate methods to which reference is made (14, 15) has been tested.

Allen (12) gives a method using a solution of potassium dichromate in approximately 40 per cent. sulphuric acid. The standard solution is made up by dissolving 16.97 g. pure potassium dichromate in 200 c.c. of distilled water and then making up to 1000 c.c. with 50 per cent. sulphuric acid. The excess of dichromate after oxidation of the alcohol is estimated by titrating with standard ( $\frac{N}{10}$ ) thio-sulphate the iodine liberated on the addition of potassium iodide to the reaction mixture after dilution with 200 c.c. of water. In this method oxidation proceeds to the acetic acid stage, so that 1 c.c. of the dichromate is equivalent to 0.005305 g. of alcohol.

A large number of experiments have been carried out using a standard alcohol solution of such a strength as is expected to be obtained in the later work. The heating of the solution has been varied from slow to rapid, from heating only to 80° C. or to boiling for varying periods of time, but satisfactory results have not been obtained. Allen merely states that the solution is to be heated until a green but not a greenish-yellow tint is reached, but the difficulty is to decide when the solution has reached the right stage since the experiments described here have shown that although visually the solutions are at the same stage, the oxidation has not proceeded to the same degree; indeed, in many cases, oxidation must have gone beyond the acetic acid stage to explain the large consumption of dichromate. The results are very erratic, sometimes low, sometimes high, and sometimes approximately correct, although the tendency is distinctly towards high results.

In all cases the total volume of reaction mixture was about 150 c.c. Heating must be carried out carefully, especially in the early stages, otherwise loss of alcohol occurs.

Table 2 contains some of the results obtained when the various factors governing the oxidation were altered.

Table 2.

Alcohol mg.		Error per cent.	Dichromate solution c.c.	Heating	
Theory	Found			Temp. °C.	Time mins.
108.3	107.2	−1.0	27.0	(Boiled)	10
108.3	117.8	+8.8	25.0	(Boiled)	20
108.3	113.5*	+4.8	23.0	80	10
108.3	117.2*	+8.2	23.0	85	10
108.3	109.0	+0.6	23.0	85	10
104.7	101.1	−3.4	21.1	90	2
104.7	105.3	+0.6	22.0	90	5
104.7	110.3	+5.4	22.0	90	15
104.7	106.0	+1.3	23.0	80	15
104.7	109.2	+4.3	23.0	75	20

\*In each of these cases 10 c.c. of concentrated sulphuric acid were added to the reaction mixture.

In the other method (13) using potassium dichromate as oxidizing agent, the whole reaction is carried out in concentrated sulphuric acid. The solution is made up by dissolving 4.4128 g. of pure dichromate in as small a volume of water as possible and then making up to 1000 c.c. with concentrated sulphuric acid, being careful to add the acid slowly, so that at no time shall the temperature rise above 100° C. At a certain stage the chromic oxide precipitates out but readily redissolves when more acid is added. From a burette a measured quantity of the solution is run slowly into a cold mixture of a known volume of alcoholic solution with three times its volume of concentrated sulphuric acid, which has been added slowly, keeping the flask cool under the water tap. The mixture is then slowly heated to 98° C. (not above) and the temperature held there for exactly five minutes. After cooling the liquid is diluted with 200 c.c. of cold water, and after cooling again the excess dichromate is destroyed by excess of standard ferrous ammonium sulphate solution, this excess in turn being estimated with standard permanganate.

The method sounds long and involved, but in practice it is rapid, and gives accurate and reproducible results. In very few cases did the quantity of alcohol present in the volume of liquid taken exceed 10 mg., and in the great majority of cases it was considerably less than this.

In Table 3 are given the results of experiments made to test the accuracy of the method using alcoholic solutions of known strength. Solution A was made up from industrial absolute alcohol which was taken to be 99.5 per cent. pure, but in reality may have been only 98 per cent; which would explain the low results of the first three experiments as compared with the experiments using solution B for the making of which pure alcohol was used.

Table 3.

Solution	Alcohol mg.		Error per cent.	c.c. conc. sulph. acid per 10 c.c. of solution.
	Theory	Found		
A	10.56	10.21	—3.0	30
A	12.15	11.95	—1.7	23
A	21.12	20.70	—1.5	25
B	20.00	19.95	—0.25	30
B	20.00	20.06	+0.30	30

It is necessary to point out that this method cannot be used in the presence of chlorides as evolution of chlorine occurs and high results are obtained. Thus a given quantity of solution contained 10.56 mg. of alcohol; after adding 1 c.c. of  $\frac{N}{10}$  sodium chloride and treating as above an apparent result of 12.27 mg. was obtained. Silver sulphate may be used to remove chloride.

An alcoholic soda solution, prepared for use in the main series of experiments, was then analyzed by the above method. Into a weighing bottle were rapidly placed 10.2940 g. of this solution which were

afterwards diluted to 1,000 c.c. with distilled water. Of this dilute solution 15 c.c. were taken for analysis. Six experiments were made using two different lots of dichromate solution. The mean values for the alcohol content from the two sets were 7.75 per cent. and 7.60 per cent. respectively; in no case did the extremes in each set differ by more than 0.1 per cent.

A large number of analyses have been carried out using this method when even as little as 0.05 g. of approximately 10 per cent. alcoholic solution (which had to be diluted down to 100 c.c. before estimation) was available, and it can be confidently stated that accurate results are obtained when reasonable care is observed.

The list of references refers more particularly to methods in which the evolved carbon dioxide is estimated. In the second class the methods are for ethyl alcohol only.

### Summary.

1. Carbon may be estimated by wet combustion with dichromate in acid solution when present in non-volatile compounds.
2. Ethyl alcohol may be estimated by volumetric methods even in very dilute solution; attention is drawn particularly to Benedict and Norris' modification of the method which can be used when only 0.01 per cent. of alcohol is present.

The above experiments were carried out at the Imperial College of Science and Technology, South Kensington, London.

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## Reviews.

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### THE CORRELATION OF IRON STARVATION IN RUMINANTS WITH THE PHYSICAL FEATURES OF THE COUNTRY.

R. E. R. GRIMMETT, M.Sc. (Analyst, Department of Agriculture), in the *New Zealand Journal of Agriculture*, vol. 34. No. 5, pages 289 to 294, May, 1927), after a year's residence at Rotorua spent in a continuous study of the field conditions in the "bush sick" area, has made a contribution to the knowledge of this remarkable deficiency disease in ruminants, now officially known as "Iron Starvation" (see *Transactions New Zealand Institute*, vol. 55, 1924, pages 720 to 723).

Grimmett considers that on typical "bush sick" farms, five conditions will always be present, viz.:—

(1) The surface soil is sufficiently elevated above the permanent soil water-table to prevent the rise by capillary attraction of ground water from the water-table to the surface soil.

(2) The surface soil is always of very coarse texture, being coarser than what is known in soil science as a sandy loam; that is, a soil on which the disease occurs always contains less than five per cent. of clay, or does not contain an amount of decayed vegetable matter ("humus") which would in its action be equivalent to five per cent. of clay.

(3) The subsoil and substrata are always fairly pervious to water.

(4) The annual rainfall is fairly heavy.

(5) The surface topography is that of an approximately horizontal, undissected type of country, and, which follows really as a corollary, there is an absence of seepage areas.

The author explains that the elevated, highly oxygenated porous soil is in an ideal condition for losing by leaching when subjected to a heavy rainfall, the plant foods soluble in water, or for losing by oxidation such compounds as those of ferrous iron, which are taken up by the plant in the reduced state, being unavailable in the more highly oxidised state, e.g., ferric iron.

If five per cent. of clay or an equivalent amount of organic matter be present, the excessive loss of soil water (carrying its load of plant food) by drainage is retarded, and the oxidation is hindered. Also, if near the surface there exists a semipervious substratum such as an alluvial silt layer or a pan, the downward flow of water is checked, encouraging an increase in the run-off and the consequent development of springs and swamps, conditions favouring the solubility or availability of iron.

With a porous soil, the heavier the rainfall the greater will be the leaching. The disease usually appears to be most prevalent in very

wet seasons. If the topography be one of very sharp ridges and valleys, or of steep slopes, leaching will be modified in two directions: (1) The ratio of soakage to run-off will be lowered, less water sinking into the soil, or sinking through in more restricted areas; (2) The water which does soak through and leach the higher levels will often seep out again, bearing its load of soluble plant food to the plants at lower levels. In such a case where seepage springs and creeks are bordered by swampy pasture, even in relatively small areas, stock having access to the pasture do not develop iron starvation. If the springs are localized, or the streams sharply entrenched so as to leave no room for wet seepage or unacrated soil pasture, the incidence of the disease is but little affected.

Some examples of how the various factors operate together to produce the different degrees of iron starvation actually observed may be given. On portions of the Kapakapa Road, and at Te Pu and Ngawaro (Rotorua County), perhaps the most acute degree of the disease is manifest. All the factors enumerated are present (see *N.Z. Journal of Agriculture* for January, 1925, p. 2). The situation is relatively high above permanent water, the soil is a fine gravelly sand or a coarse sand, the substrata are pervious, consisting of sands and tuffs, the topography is that of a plateau, or is gently valleyed and hummocky, and the rainfall is heavy, resulting in a leached soil and an absence of springs and seepage areas.

At Mamaku, the chief factor modified is the texture of the soil, which is a sandy silt, rather fine and less pervious than the soils mentioned above. Sickness is less acute, but still severe (see *N.Z. Journ. Agr.*, vol. 29, November, 1924, page 324).

At Oturoa the soil is finer, being a sandy loam, and the altitude less. Springs and creeks occur. Sickness is absent or of a light degree.

Farms at the blind ends of Kapakapa and Kaharoa Roads, and in parts of Ngāwaro and on the northern side of Rotoiti Lake, are either free, or exhibit only a mild form of the trouble. The soils and other factors are practically the same here as in other parts of the Kaharoa and Ngawaro districts, with the exception of topography, which is usually found to be well dissected, with springs, swamps and seepage areas, and streams.

At Hamurana, and generally on the low-lying land bordering the lakes, not only is no sickness found, but sick animals from other areas recover quite rapidly. The soils vary from sandy silts to fine gravelly sands, and the only modified factor appears to be the altitude above permanent water, which is often but a few feet, or even inches, and in winter some land may be submerged. Springs, seepage areas, and swamps, occur under the hills and higher terraces to the lake edge.

The higher terrace lands, which are intermediate in altitude and position between the low-lying healthy lakeside soils (as at Rotorua) and the high sick soils (as at Mamaku) are also found to be intermediate as regards the incidence of sickness.

At Te Ngae, Okareka, and other places where sufficient thickness of the 1886 Rotomahana eruption mud remains to form a new surface soil, no sickness either in cattle or sheep occurs, even on the high flattish land with a coarse pumice subsoil. Apparently the fact that the soil is a sandy loam with over five per cent. of clay is largely responsible for this immunity. In addition, little time has elapsed for leaching to occur; iron is present in considerable quantity, and, judging by the colour (bluish grey), is not greatly oxidized.

The road from Rotorua to Atiamuri passes through a large area of country the surface soil of which, generally of coarse texture,\* is derived from subaerially deposited pumice, as in the remainder of the district. This deposit varies in depth from 1ft. to 4ft., the substrata consisting of alluvial deposits varying from coarse water-worn gravel to well-sorted sands, silts, and clays of a compact and fairly impervious nature. Excessive leaching of the top-soil seems thereby to have been prevented, and the run-off of rain-water and the formation of springs, streams, swamps, and seepage areas greatly increased. Thus, despite the presence of other factors favouring iron starvation, this does not appear to have been experienced where farming on this area has been carried out.

### REMEDIAL TREATMENT FOR IRON-STARVATION.

Remedial treatment may be sought in three different directions: (1) By supplying iron to the animal direct; (2) by supplying iron to the pasture direct, either through the leaves or through the roots; (3) by sufficiently modifying any of the factors contributing to the present unavailability of the iron in the soil.

1. Feeding of iron salts to the animal, particularly iron ammonium citrate as originally introduced by Mr. Aston, is meeting with very general success, but obviously has limitations. Its greatest usefulness is found in the case of dairy cows, where the supplying of a regular ration is a fairly simple operation.

2. The supplying of iron to the pasture is being experimented with, ferrous sulphate being used both as a soil top-dressing and as a weak spray applied to the green growth. So long as the conditions which contribute to the unavailability of the natural iron in the soil remain unaltered, it seems unlikely that the application of soluble iron salts to the soil will be of more than temporary benefit, the application needing to be renewed at fairly frequent intervals.

3. Modification of contributory factors:—

(a) The attitude of the surface soil above the permanent water-table can scarcely be modified by human agency.

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\*Since the above was written, some of these topsoils have been found by analysis in this Laboratory to be much finer (belonging to the type called silts) than most pumice soils, a fact which may somewhat modify the opinions in this paragraph.

(b) Texture of the soil: Of the two possible ways in which this could be amended—namely, by increasing either the clay or the humus—the latter is alone likely to be practicable. As recommended by Aston (*N.Z. Jour. Agr.* for August, 1912, p. 122, May, 1912, p. 377, and August, 1924, p. 90) of all avenues open to the farmer, green manuring appears to be the most immediately promising for diminishing the trouble. By this means a closer and less pervious structure is given to the soil, the store of material capable of reducing the insoluble ferric to the more soluble ferrous form of iron salts is added to, and the general fertility of the soil increased. Somewhat the same end is attained by the establishment of a close and well-compacted turf of approved pasture plants; and it is probably for this reason that with ageing of the pasture iron starvation generally diminishes, while reploughing and resowing is said frequently to produce a temporary return to a more acute stage. Rolling, trampling by stock, or other means of consolidation also should be beneficial, both by decreasing the air space in the soil and by tending to restrict soakage and leaching.

(c) Neither the nature of the substrata nor (d) the amount of rainfall, nor (e) the general nature of the topography are factors amenable to practical control.

(f) Building up of the store of iron in the soil should be aimed at, even though much of it may be rendered for the time being practically unavailable. Especially is the use of basic slag (or, better still, of a slag super mixture), or a mixture of iron sulphate with superphosphate likely to be beneficial, as the phosphate encourages root growth, and by bringing the roots into close association with the iron, may tend towards a greater degree of absorption. Mr. Aston has recently recommended the trial of "ferrous superphosphate," a mixture of superphosphate, sulphate of iron (hydrated ferrous sulphate), and hydrated sulphate of lime (gypsum). This mixture contains 12 per cent. of iron sulphate (see Griffiths's *Treatise on Manures*, 1892, p. 283, Whittaker, London).

(g) The utilization of any areas of seepage, swamp, or river flat existing on "bush-sick" farms should be zealously aimed at, pasture grown under such conditions being usually rich in iron and an antidote to the sickness.

To make his paper complete, the reviewer here summarizes some of the remedial treatment recommended or adopted at the Government Farm, Mamaku, as the result of many years' experience of officers who have assisted in this investigation, together with some recommendations of his own. This may be compared with the last authoritative advice published by the Department (see *N.Z. Journ. Agr.*, vol. 33, p. 98):—

"(1) Farm more highly; get the plough in; compact the soil; grow plenty of winter feed, and save plenty of hay; subdivide into smaller paddocks, and keep the pasture eaten short. Topdress with phosphate—preferably containing iron, or in conjunction with iron sulphate—as frequently as is the practice to topdress in the Waikato. Treat the stock well, especially in the matter of water-supply.

“(2) Use molasses freely in the feeding, especially in the rearing of young stock. Regard molasses as a preventive, but not as a cure.

“(3) When an animal shows signs of going back in condition owing to iron hunger, give iron ammonium citrate as supplied by the Mamaku Demonstration Farm, and by the Stock Inspectors at Rotorua and Tauranga, at a cost price to bonafide farmers.

“(4) Buy any stock required from districts remote from the affected pumice land, and under conditions which ensure that the animals are free from disease or parasitic infection. Lack of the mineral elements is known to predispose an animal to other diseases and ailments, which, when introduced on to a farm on sick country, run a rapid course in the stock.”

The use of molasses (first introduced to the Department by Mr. Norman Callister, farmer, Te Puke), is still advocated by the Department as is the use of winter feed (hay, roots, etc.). Also new stock brought on to the farm should comply with condition No. 4.

The value of Grimmett's contribution lies in his production of further evidence towards the theory that “bush sickness” is iron starvation; his testimony to the value of green manuring, or of reinforcing the organic matter (humus) of the soil; his support to the explanation previously advanced (*N.Z. Journ. Agri.*, December, 1924, p. 370) by which it is sought to explain why the disease occurs on some lands and not on others nearby of similar mechanical composition. But he does more than endorse theories long held, for he has by the careful examination of the physiography of many examples of sick and healthy lands occurring in close proximity, been able to distinguish the surface features which characterize a typical “bush-sick” farm, from those features which characterize healthy country in such a way that typically bad country may be recognized from typically good country.

B. C. ASTON.

## "THE INSECTS OF AUSTRALIA AND NEW ZEALAND,"

By R. J. TILLYARD.

560 xi pp. Angus &amp; Robertson, Ltd., Sydney.

Price 42/-.

SINCE the publication some years ago of Mr. G. V. Hudson's "New Zealand Neuroptera," "New Zealand Moths and Butterflies," and "Manual of New Zealand Entomology," and Mr. W. W. Grogatt's "Australian Insects." Dr. Tillyard's "Insects of Australia and New Zealand" is the first comprehensive work on Australasian entomology to be published.

Dr. Tillyard's book consists of 560 pages with numerous illustrations. There are 30 chapters and two appendices. The first four chapters, covering 45 pages, are devoted to classification, morphology and life-history. Chapters 5-28 comprise the bulk of the book, each of these chapters being devoted to the discussion of 24 orders. Chapter 29 deals with palaeontology and origin of Australian insects, while chapter 30 is devoted to methods for collecting and preserving insects. The first appendix is a glossary and the second a key to author's names. The whole closes with a fairly extensive index.

A noticeable feature is that of the 475 text figures, 456 are original, while of the 44 full page plates, 27 are photographic, 9 wash drawings, and 8 are in colour, all but one of the plates being original. The illustrations are the work of Dr. Tillyard himself and five others. The text figures on the whole are excellent for interpreting group characters, though some are not specifically accurate. For instance, in fig. R 83, important structural characters of the rostrum are not shown. Fig. R 62 does not feature the larva of *Prionophus reticularis*, accurately, the anal segment being particularly noticeable in this respect. In fig. W 56 the thoracic chaetotaxy (of systematic importance) has been drawn without sufficient consideration of its arrangement. The detailed labelling of the drawings is a commendable feature and one usually overlooked by most book writers. Through an oversight figures R 83 and R 84 have been transposed. The plates are good with the exception of the photographs of certain species which lack detail, a very difficult object to attain with many insects. It might be pointed out (see p. 368) that *Syrphus viridiceps* occurs in New Zealand as well as in Australia; and in *Ichneutica* (p. 442) there are seven species in New Zealand, not only two as stated.

In the classification 24 orders are characterized, and a table shows that of the world's total insect population of 490,000 species 37,000 occur in Australia and 8,000 in New Zealand. The account of morphology and life history is brief but very much to the point, especially from the systematist's viewpoint, and forms the basis for an understanding of the characters of individual orders discussed further on in the book. With regard to wing-venation, though the classical attempt by Comstock and Needham to homologize the venational variations of the Pterygota went a long way to solve the problem,

there were left many fundamental difficulties. Dr. Tillyard has been able, from his recent studies of fossil insects, to throw light upon many debatable points. He has put forward a feasible scheme on the homologies of the more intricate venational variations, at the same time showing more definitely the relationship of, and lines of evolution followed by, the different insect orders. Though the general scheme of classification followed in the book is that generally accepted, the author has made an interesting regrouping of orders and families according to the results of his extensive studies of palaeontology and evolution.

In the chapter on life-history an agreeable feature is the dropping of the term "nymph" as applied to the larvae of hemimetabolous insects. The information summarized in this chapter is sufficient for the purposes of the book, which deals mainly with adult characteristics; but references here to figures, wherever they occur illustrating immature stages in late chapters, would have been helpful to the student.

In the 24 chapters dealing with orders, a definite system is adhered to throughout. Each order is discussed according to characters, life-history, distribution, fossil history, economics and distribution. The economic aspect is not stressed and, as is pointed out in the preface, the book is not one on economic entomology, but rather on classification and morphology, a fundamental knowledge of which is essential to the student. The information in these chapters is very great and of the utmost value, being a well-digested summary of information a great deal of which is original. Keys are given to enable the student to place an insect, in its family at least; and of great assistance are the tables comparing the different venational terminology of each order with the author's amended system.

In the 29th chapter dealing with fossils Dr. Tillyard through his palaeontological researches has brought to light a vast amount of valuable information and so has filled in gaps in the fossil record.

D.M.

## OBITUARY.

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### WILLIAM TOWNSON, 1850-1926.

WILLIAM TOWNSON was born at Liverpool, England, in 1850, came to New Zealand as a young man, and died at the Thames on 11th August, 1926.

Townson was at first educated with a view to qualifying for medicine, his father, Dr. Benjamin Townson, being a Liverpool medical man; but he chose to become a pharmaceutical chemist, a business he carried on for nearly forty years in various parts of New Zealand.



Moving from one town to another, he had opportunity to study the plants of widely separated districts. Townson made collections on the Tararua Range (Mt. Holdsworth), the volcanoes, Mount's Ruapehu and Egmont, and from the mountains near his last home at Thames.

The North Island had been well examined by other collectors, so that Townson's chief work must be accounted that carried out in the South Island. Townson thus acquired an excellent knowledge of the flowering plants and ferns over a very large part of New Zealand.

His one paper to the *Transactions* was that on the vegetation of the Westport district, with a list of plants. Concerning his work, Cheeseman (*Manual of the New Zealand Flora*, p. xxxiv) says:—

“During the last five years, Mr. W. Townson, of Westport, has diligently explored the greater portion of south-western Nelson, from the Mokihinui River southwards to the Grey River, repeatedly ascending all the higher peaks of the coast ranges, as Mount Frederic, Mount Rochfort, Mount William, Mount Faraday, Mount Buckland, etc. He has also visited the Lyell Mountains, and many of the high peaks flanking the Buller Valley, as far up the river as Mount Murchison and Mount Owen. Most of this large district had never been carefully examined for plants, and Mr. Townson has consequently reaped a rich harvest of novelties, most of which are described in this work. Among them are *Aciphylla Townsoni*, *Celmisia dubia*, *Dracophyllum Townsoni*, and *D. pubescens*, *Gentiana Townsoni*, *Veronica divergens* and *V. coarctata*, and the interesting new genus of Orchideae, which I have named in his honour *Townsonia*. Mr. Townson's specimens, which have been collected with great care and judgment, have been mainly forwarded to me for the purpose of this work, and have proved of much service in determining many questions relating to the geographical range of the species.”

Townson's work in Westland was no doubt of great value to Cheeseman when preparing his work on the systematic botany of New Zealand. Townson's observations, especially those dealing with the altitudinal range of species, are valuable, but would have been of much more assistance to students of ecology, had he given some indication of the relative abundance of the commoner plants in the different types of country he so often traversed, including the *pakihi*, a type characteristic only of the Nelson and Westland area, the salt mud-flats, the forests, the scrubs, and the mountain tops. These all yielded merely their rarities to him, though now and then he gives a complete list of plants of some definite association.

Townson was of a modest, gentle disposition, but full of energy and enthusiasm. He had many sides to his character, and lived a full life, cultivating many branches of knowledge, helping in every good work, a friend to all who sought to learn the secrets of nature, a lover of music, good literature, and gardening. He was a student of Maori customs and traditions, and a keen collector of specimens of Maori workmanship. He had a good knowledge of the birds of New Zealand, and communicated notes on that subject to the press. He was no mean chess player for he held the championship cup of the Thames Club.

Townson was no recluse. After a week spent in attempts to alleviate human suffering, it was his joy to visit the mountains, but he also found time to be an active church worker and to meet others in furtherance of some design for the common good, for culture, or for relaxation.

The Rev. James Milne, M.A., in a tribute to his memory in the *Thames Star* says:—

“Townson, without doubt, found reward in the work itself. He loved to roam over his beloved hills and mountains, his face aglow with ruddy health, his eyes shining with zeal for something new, or higher heights to climb.”

In his youth he suffered from chest complaint, but he struggled manfully, and how well he ultimately succeeded in outgrowing his weakness one may read between the lines in his Westport travels:—(*Transactions of New Zealand Institute*, Vol. 39, p. 380.) “I have never regretted consenting to prepare this list, although I had no conception that it would prove to be such a big undertaking, for thousands of miles had to be walked, over hill country and plain, in fair weather and foul, and numerous difficulties had to be surmounted. But in looking back upon these years of wandering, when all my senses were on the alert, and my thews and sinews were strung to stand the strain of the longest day’s tramp, when the book of nature was no more a sealed book for me, and the trees, plants, and birds became my familiar friends, they were undoubtedly the happiest years of my life.”

Well, indeed, might he have cried with the psalmist, “I will lift up mine eyes unto the hills, from whence cometh my help.”

B. C. ASTON.



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## The External Distribution of the New Zealand Marine Algae and Notes on Some Algological Problems.

By ROBT. M. LAING, B.Sc., F.N.Z. Inst.

[Read before the Meeting of the N.Z. Institute at Dunedin, January 29th, 1926; received by Editor, 30th November, 1926; issued separately, 18th October, 1927.]

In 1895 in a paper entitled "The Algae of New Zealand, their Characteristics and Distribution," I considered to some extent, the phytogeographical problems that our seaweeds present. I had then only some three hundred species to deal with. Now there are some five hundred known, and I wish to raise again some of the same questions as before, basing my comments on my "Reference List of New Zealand Seaweeds 1926." I shall omit from consideration the Myxophyceae, which have scarcely been observed in New Zealand. Indeed, in the other groups also, considerations derived from our present acquaintanceship with the distribution of the Marine Algae, can only be preliminary to a future discussion in which our knowledge will be wider and more accurate than at present; but even with our present very limited information, as to the species their range and relationships, some consideration of outstanding problems should be a guide to future research.

The internal distribution is not here considered, as too little is known of it, to enable one to deal with it adequately but there are wide differences between the algal flora, for example, of the Bay of Islands and of the Bluff, and wider still between those of the Kermadecs and the Auckland Islands. Still such differences are perhaps not greater than those that would be found elsewhere between sub-tropical and sub-Arctic or sub-Antarctic regions. In many cases too the distribution of a species is discontinuous, and it is then very easy to be misled as to its range. For such reasons it seems wiser at present to confine one's comments to the external distribution. A few notes however, may be made to emphasize the above statements. In the Kermadecs such sub-tropical species as *Gymnosorus nigrescens*, *Taonia australisica* and a *Galaxaura*, are found, and a *Liagora* is known from Little Barrier Island. On the other hand sub-Antarctic species such as *Desmarestia Willii*, *Scytothamnus fasciculatus*, are known from the Auckland Islands, thus showing a definite North and South distribution dependent on temperature. There are many other species or genera which are confined chiefly or entirely to the North Island, whilst others are only found in the South Island. Thus several more species of the tropical genus *Caulerpa* are to be found in the North than in the South Island; whereas, on the other hand *Cladophoras* are confined to the southern portions of New Zealand, and are not known north of Otago. Species of *Callophyllis*, *Apophlaea*, *Euzoniella* and certain *Delesserias* and *Nitophyllums* are southern rather than northern. Though the Fucales are fairly evenly distributed through

both Islands, yet *Carpophyllum elongatum* is not known south of the Bay of Islands, *C. plumosum* is chiefly a North Island species, whilst the *Cystophoras* are better developed in the South than in the North. *Landsburgia* is apparently most abundant in the neighbourhood of Cooks Straits, whilst a distinct species is known from the Chathams. These distinctions might be indefinitely multiplied, but so little is known of the content of many parts of the coast line and the special habitats of many species, that it is unsafe to venture very far on such generalizations.

I shall now endeavour first to follow out the argument of my earlier paper, and show how it has been modified by our increased knowledge, and then deal with the questions raised in a more general way. The increase in the number of recognised species may be shown briefly thus:—

	1894.	1925.	British.
Chlorophyceae	24	45	87
Phaeophyceae	55	88	142
Rhodophyceae	228	390	237
	<hr/> 307	<hr/> 503	<hr/> 466

The list of British species is based on that of Holmes and Batters, which is the last complete list available. No doubt it could now be considerably extended. The one unmistakable point of contrast is the much greater richness of the New Zealand waters in Rhodophyceae. Varieties in both lists have been omitted, and similar groups only have been compared. Doubtless further investigations will show that New Zealand waters are as rich as those of Great Britain in Chlorophyceae; and possibly also in Phaeophyceae. There are, for example, over thirty-five Ectocarpaceae in Great Britain, while only four are recorded from New Zealand. These are imperfectly known, and there are doubtless many more to be discovered.

It should also be noted that the two New Zealand lists—owing to certain alterations in the classification—are not strictly comparable. The transference of the Bangiales from the Chlorophyceae to the Proto-Florideae reduces the one group in the 1925 list and increases the other. In spite of this change the percentage of the Chlorophyceae has been increased in comparison with the Phaeophyceae; and now numbers fifty-two per cent. instead of the earlier forty-four per cent. However, little guidance can be obtained from these percentages, which will fluctuate largely with the nature of the investigations carried on, and which of course only correspond very roughly with the number of species actually present in the country. The comparison with Great Britain—an area of equal extent in a similar latitude—shows that in these proportions we have a typically temperate flora. The high percentage of Florideae is doubtless due to the wide North and South range of our coasts; and not to any peculiar richness in the group. We have moreover an algal Flora averaging about three species to the genus. Hence we cannot in any way regard it as fragmentary or Oceanic in type, though certain small families of northern waters are missing from it. Figures for comparison may

be found in Murray, 1893, p. 70. Apart from geographic considerations, sea temperature is probably the chief controlling factor in the distribution of the seaweeds. The Florideae being generally shade plants, or more often submerged altogether, must depend more than the Chlorophyceae or the Phaeophyceae upon sea temperatures. Other seaweeds being exposed, at low tide depend for their existence upon such additional factors, as surface temperatures and the humidity of the air, the nature of the coast, the salinity of the water, the amount of light received, and the times of neap and spring tides. There are other ecological factors at work in determining distribution, but it is not proposed to deal with these in this paper in considering the general external distribution.

In this respect, the first point to be noted is the amount of specific endemism. This is small compared with that of the flowering plants amounting only to about forty-one per cent., while high compared with that amongst the seaweeds in most other regions of the world, though it is difficult to obtain suitable figures for comparison with similar districts elsewhere. Great Britain, of course, is the most similar area, and there the endemism is almost negligible, as might be expected, from its situation in the midst of the land masses of the world. As Cockayne has pointed out (1921, p. 311) the endemism amongst the New Zealand Dicotyledon rises as high as eighty-five per cent.; and though for obvious reasons the marine algae are comparatively widely distributed, it is quite possible that in them the amount of endemism rises higher than elsewhere, except perhaps in Australia, where there is a remarkable number of endemic Floridean genera.

Yet, whilst in the case of the flowering plants, increasing knowledge has tended to increase the percentage of known endemism, here it has tended to decrease it. In 1894, I estimated it as fifty-two per cent. It now appears as forty-one per cent. This decrease is largely due to the increased number of species, now known to be common to New Zealand and Australia. Whereas I previously estimated our Australian element to be only fifteen per cent. of the total, it now appears to be thirty per cent. On the other hand, the percentage of what we would now term sub-Antarctic species has considerably decreased, though it is still a noteworthy feature of the list, amounting to perhaps seven per cent. This includes a very few forms which are also found in the Antarctic proper, *e.g.*, *Ballia callitricha* and *B. hombroniana*, but generally speaking there is no distinct element in New Zealand seaweeds which can be recognised as purely Antarctic. The widely distributed species amount to about sixteen per cent. in both lists. The remaining species (six per cent.) are those with wide but often discontinuous distribution, amongst which may perhaps be traced a small and scarcely noteworthy Polynesian element. We thus get the following results, which I now wish to consider, somewhat more in detail:—

Endemic	.....	.....	.....	41 per cent.
Australasian	.....	.....	.....	30   "   "
Sub-Antarctic	.....	.....	.....	7   "   "
Widely distributed	.....	.....	.....	16   "   "
Miscellaneous	.....	.....	.....	6   "   "

Now let us consider the endemic element. Dr. Cockayne (l. c. p. 311) defines five degrees of specific endemism; but it will be quite impossible to follow his arrangement here. However, it may be borne in mind, and we may at least distinguish those species, that show endemism of the first degree. These are those which belong to endemic genera, sub-genera, and distinct sections of genera. Now our endemic genera are twelve in number, \**Ptilopogon*, *Herponema*, *Marginaria*, *Landsburgia*, *Craspedocarpus*, *Apophlaca*, *Abroteia*, *Streblocadia*, *Microcolax*, *Pleurostichidium*, *Pandorea*, and *Dacytlymenia*. These may be regarded as a distinctively New Zealand element, involving eighteen species. Most of them require more investigation than they have received. *Marginaria* with two species is a most distinct fucaceous genus, whose reproduction has not yet been fully worked out, and a detailed account of it is much to be desired. *Landsburgia* though perhaps not so distinctive is in a similar position. It has also two species, one on the main islands, and one on the Chathams. *Apophlaca* again with two species, is a red seaweed of quite uncertain position. *Pleurostichidium* is a remarkable and little known Floridean parasitic on a brown, an unusual occurrence. *Pandorea* belongs to the *Ceramiales*, is monotypic and quite insufficiently known. The other endemic genera are less aberrant, and more closely resemble forms known elsewhere, and will not be further considered here. They are usually monotypic. It may, however, be noted that none of these genera belong to the Chlorophyceae which are usually widely distributed, that eight are Floridean, and four Phaeophyceae. Three, *Herponema*, *Microcolax*, and *Pleurostichidium*, are parasitic.

Associated with these endemic genera, are those which though not confined to New Zealand have a distinctively New Zealand section, or those whose species are chiefly confined to New Zealand. Amongst these may be mentioned *Carpophyllum* (which, however, is closely related to the widely distributed *Sargassum*), *Cladhymenia*, *Euzoniella*, and *Pachymenia*. The New Zealand species of these genera are probably not so distinctive as those in the first group. They would still, however, come under Cockayne's definition of specific endemism in the first degree (*Metamorphe* and *Aeodes* until recently have been regarded as monotypic endemic genera, but the same or another species has in each case, recently been found in the North Pacific). This gives us another fifteen species to add to our previous eighteen, making in all a total of thirty-three, which show specific endemism of the first degree.

Here is perhaps the place to mention the algal genera confined to New Zealand and Australia. They are nineteen in number, viz., *Perithalia*, *Notheia*, *Hormosira*, *Xiphophora*, *Cystophora*, *Gloiophonia*, *Mychodea*, *Dicranema*, *Areschougia*, *Melanthalia*, *Curdiaea*, *Sarcocladia*, *Hymenocladia*, *Hemineura*, *Phytomphora*, *Aphanocladia*, *Lenormandia*, *Warrenia*, *Thamnoclonium*. Several other genera are confined to New Zealand, Australia, and the Cape of Good Hope. It

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\*Since writing the above, I find, from Sauvageau, 1900-1914, p. 480, that *Ptilopogon*, has also been found at Port Phillip (Australia).

is clear, therefore, that the general distribution of the southern element is, as might be expected, of an east and west character. In such genera, however, as *Notheia*, *Hormosira*, *Xiphophora*, *Cystophora*, *Melanthalia*, *Cordiaea*, *Sarcocladia*, and *Hymenocladia*, sufficient distinctiveness is shown to constitute Australasia as a distinct algal region, and it should be so considered in the future.

The majority of the remaining New Zealand endemic species would no doubt appear under Cockayne's classification as showing endemism in the fourth degree. Many of them are found in the large, world-wide genera such as *Nitophyllum*, *Gigartina*, and *Polysiphonia*. It would serve no good purpose in the present state of our knowledge to attempt any further analysis of this form of specific endemism. However, something must be said about the distribution of the endemics through the sub-classes and families. In the Chlorophyceae there are only nine, and of these seven occur in the genus *Cladophora*. This number is quite likely to be reduced by further exploration in adjacent countries and islands. The cosmopolitan nature of the Ulvaceae at any rate is well known, and possibly to be attributed to their great age, rather than to special means of distribution. No doubt, however, there are still a considerable number of the smaller Chlorophyceae yet to be listed.

With the Phaeophyceae it is different. Our brown seaweeds are almost exclusively Australian in their relationships. With the exception of the endemic species already dealt with, one or two sub-Antarctic species from the Aucklands, *Lessonia variegata* and several doubtful cases, all our known Phaeophyceae are also found in Australia, and, as we have already seen, many of the most remarkable. (e.g., *Notheia*, *Hormosira*, *Xiphophora*, *Perithalia*) belong to distinctively Australasian genera. Our Fucaceae, indeed, are all Australasian if not endemic, with the exception of *D'Urvillea*, which though South Australian, is chiefly sub-Antarctic in its distribution. This is a remarkable fact, and I do not think the relationship can be attributed purely to drift across the Tasman sea in currents from the west driving before westerly winds, particularly when we remember that the Laminarians on the other hand, though more widely distributed, tend to show a sub-Antarctic facies and have their headquarters in Southern America. The Ectocarpaceae are more cosmopolitan, and are probably an older family. However, the New Zealand species are so little known, that there is little to be said about their distribution.

Not only are there a number of endemic Australasian genera, but of the thirty per cent. of our seaweeds that are also found in Australia, no less than one hundred and twenty-six, or twenty-six per cent. of the total New Zealand seaweeds, are confined to New Zealand and Australia. About one thousand Australian seaweeds are known, therefore about thirteen per cent. of the Australian seaweeds are found only in New Zealand apart from Australia. The connection is obviously a very much closer one than it is for the Phanerogams; and it is not altogether represented by showing percentages. The numbers of individuals have to be considered. One may traverse the Australian forest for days and see few New Zealand species, and

those in small quantity, but if one goes to the sea-shore at Sydney or Melbourne the New Zealand species of seaweed are much in evidence. Possibly, but not probably, ocean currents are responsible for this close connection. In this case one might expect to find more Australian species on the west than on the east coast of New Zealand; but much of the West Coast is poor collecting ground, and in any case there has been but little examination of it. What is particularly required is a close examination of the species common to both Floras, and this has yet to be done. The Australian element of our algal flora contains, further, a distinct Malayan group, which, however, scarcely needs discussion.

The next element of especial interest is that now known as the sub-Antarctic. The term has been loosely and variously used by different writers. It is proposed here to consider the Antarctic as that region bounded by the northern limit of pack-ice; and the sub-Antarctic as bounded by the northern limit of drift-ice. Thus defined the Antarctic will include the Antarctic continent. The sub-Antarctic is entirely insular and includes Tierra del Fuego, the Falklands, South Georgia, Tristan da Cunha, the Crozets, Kerguelen, the Aucklands, and Campbell Island, with various other small islands. As is well known, these islands show striking resemblances in their animal and vegetable life, and for biological purposes form a well-marked region. When species from these groups pass northward into Tasmania, Southern Australia, New Zealand, and South Africa, they constitute a distinct element in the flora, which may be termed the Austral-sub-Antarctic. Now this Austral-sub-Antarctic group is in New Zealand represented by thirty-five species in the seaweeds, viz.: *Chaetomorpha Darwinii*, *Halopteris funicularis*, *Halopteris hordacea*, *Scytothamnus australis*, *Adenocystis utricularis*, *Lessonia variegata*, *D'Urvillea antarctica*, *Chaetangium variolosum*, *Gigartina fissa*, *Iridaea cordata*, *I. laminarioides*, *Callophyllis variegata*, *C. tenera*, *Rhodophyllis acanthocarpa*, *R. angustifrons*, *Rhodymenia corallina*, *Nitophyllum multinerve*, *N. Smithii*, *Phycordrys quercifolia*, *Schizoneura dichotoma*, *S. Davisii*, *Ptilonia magellanica*, *Delisea pulchra*, *Chondria angustata*, *Lophurella comosa*, *L. Hookeriana*, *Poly-siphonia microcarpa*, *Herposiphonia ceratoclada*, *Griffithsia antarctica*, *Ballia callitricha*, *B. scoparia*, *Antithamnion flaccidum*, *A. ptilota*, *A. ternifolium*, *Lithothamnion antarcticum*.

There is in addition a very small element, which is sub-Antarctic proper, reaching to the Aucklands and not penetrating to the mainland of New Zealand, e.g., *Desmarestia Willii*, *Scytothamnus fasciculatus*. Now the main characteristic of these sub-Antarctic species is their wide and discontinuous distribution in south circumpolar seas. I have given reasons elsewhere (Lg., 1895, p. 305) for doubting the frequency of living seaweeds crossing wide ranges of ocean. It is true that if cystocarpic specimens of red seaweed could cross the barrier, they might at times successfully reproduce themselves, and undoubtedly some of the larger brown seaweeds occasionally migrate from coast to coast; but the present distribution shows that such occurrences are rare; and for many species doubtless quite impossible. The currents of the Pacific are still imperfectly known; but the ice-

drift from the polar regions obviously indicates northward currents round the Antarctic circle, and that these sometimes carry seaweeds is well known. Thus, speaking of the Humboldt current between 150° W., and 117° W., Captain Crutchley (1891, p. 275) states: "This current cannot be overlooked even in summer, not because of the ice contained therein only, but also because of its peculiar colour, which, in two separate years, was a dirty ultramarine, and because it contained large quantities of seaweed and various kinds of floating matter." Yet there are a number of seaweeds confined only to Antarctic seas (Skottsberg, 1907, s. 158), so it is clear that drifting weeds do not necessarily establish themselves on the shores on which they are cast. (v. also Kylin and Skottsberg, 1919, *Rhodophyceen* s. 80.) Whatever the explanation of the present distribution of our seaweeds may be, it is clear from this, as from other branches of biology (e.g., Chilton, 1909, p. 806), that the range of living forms cannot be accounted for on the supposition that the present land-masses have been permanent, i.e., the marine Algae in their present distribution tend to support such a belief in changing continental areas rather than negative it.

So far, we have been considering chiefly the east and west distribution of our species. There remains to be considered the widely ranging species that occur on both sides of the Equator, and in more oceans than one. There are, of course, a number of practically cosmopolitan species, and a larger number of genera found in all seas. Generally speaking, there seems to be—as might be expected—a rather stronger relationship with North Pacific seas, than with the North Atlantic, but this relationship is one of genera rather than species. There is a still more distinct relationship with the Indian Ocean and South Atlantic, particularly in warm-temperature and sub-tropical species. However, these remote connections are easily exaggerated, and subsequent investigations may show them slighter than now appears. Species considered to be the same in widely distant regions will be shown to be dissimilar; and this is particularly true of common European and New Zealand species. As our seaweeds have originally been examined by English and French algologists, the tendency has been to collate them with British and European species rather than with those of the North Pacific. Modern investigation, indeed, has reduced the apparent number of British species in New Zealand, so that our connection with Europe, apart from that indicated by cosmopolitan or widely distributed forms, is now known to be small or even non-existent. Amongst the brown seaweeds there is clearly no connection. This early became apparent. Hooker and Harvey, writing in the *Flora Antarctica*, vol. II., p. 45, thus discuss the distribution of the Fucoideae:—

"Throughout all latitudes the two tribes Fucoideae and Cystoseireae form that prevailing vegetation to which the name seaweed is commonly applied; and the different genera so far arrange themselves within geographical limits, as to present with such exceptions as the *Scytothalia Jacquinotii*, a most harmonic assemblage. Thus in the opposite frigid zones the waters are inhabited by certain genera of Fucoideae, which are in a great measure representative of one

another. The north cool zone *Fucus* proper and *Himanthalia* are represented in analogous southern zones by *D'Urvillea* and *Sarcophycus*. None of these genera approach the tropics, for the Fucoideae abound toward the poles, and there attain their greatest bulk diminishing rapidly towards the Equator, and ceasing some degrees from the line itself. The representatives of the Cystoseireae in the higher latitudes of the opposite hemisphere, are equally appropriate with those of the Fucoideae, for we have in the North cool zone *Cystoseira* and *Halidrys* represented in the South cool zone by *Blossvillaea* and *Scytothalia* whilst the immense genus *Sargassum* find its maximum in lower latitudes and under the Equator itself."

This passage, when considered in the light of modern ideas of classification, will have to be very much modified. Oltmanns (1922) divides the Fucales into two families the D'Urvilleaceae and the Fuaceae. In the former are placed the two genera *D'Urvillea* and *Sarcophycus* with a South circumpolar distribution. The Tahiti habitat for the former is probably erroneous. We can therefore no longer consider these two genera as representative of the northern *Fucus* and *Himanthalia*, which belong to the Fuaceae proper. The closest southern representative of *Fucus* is probably the Australasian genus *Xiphophora*, though we are still ignorant of many of the details of its structure necessary for a full classification. The section of the family to which *Himanthalia* belong is not represented in southern waters. *Scytothalia* is now also regarded as belonging to the *Fucus-Ascophyllum* group and not to the Cystoseireae. Further, the genus *Cystoseira* has recently been discovered in New Zealand (de Toni et Forti, 1923, p. 70).

Thus, it is now impossible to see the balanced arrangement in northern and southern waters that Hooker and Harvey found. Certainly the northern *Cystoseira* seems to be largely represented by the southern *Cystophora* (*Blossvillaea*), but otherwise there is no balance. We have also the anomalous genera *Hormosira* and *Notheia*, and the endemic *Landsburgia* whose position is as yet insufficiently known. On the whole, therefore, it may be stated that the members of the Fucales found in New Zealand, though so closely related to those of Australia, show very little relationship to those of European seas. In fact, with the exception of *Cystoseira*, there is not a single genus common to Great Britain and New Zealand—a disparity that it would be difficult to parallel in any other equally widespread algal family. On the other hand, most of the New Zealand genera of Chlorophyceae are also found in Great Britain, and the same will probably be found to be true for the remaining Phacophyceae with the exception of the Laminariaceae. This perhaps tends to show that the Fuaceae is the most-recently differentiated family of this sub-class.

The general distribution of the Laminariaceae has been well studied by Setchell (1893). One of the most noteworthy facts is the complete absence of the otherwise cosmopolitan genus *Laminaria* from Fuegian, Australasian, and Antarctic seas. The genus *Lessonia*, with its headquarters in Fuegia, has found its way as far north as the Ochotsk Sea in the Pacific. It is quite absent from the Atlantic. *Macrocystis* is temperate south circumpolar, but also travels up the

west coasts of America and Africa. *Ecklonia*, with a somewhat similar distribution to *Macrocystis* in the south, is apparently absent from the N.W. Pacific, where, however, it is replaced by the allied genus *Eisenia*. On the other hand, *Ecklonia* is largely represented in Japan, where *Macrocystis* is wanting. Altogether, we may say that our *Laminarians* are more closely related to those of the Northern Pacific, than of the Northern Atlantic. Apparently the only genus of the Laminariales common to New Zealand and Great Britain is *Chorda*, and in the Laminariaceae proper, there is no common genus. As in the Fucaceae the northern and southern genera are widely different. Again, the Fucaceae of the N.W. Pacific show rather more relationship to those of New Zealand, than do the Fucaceae of Northern Europe, particularly in the *Sargassum* series, for the genera *Blossevillea* (*Cystophora*) *Cystoseira*, and *Sargassum* occur in both districts, though *Blossevillea* (*Cystophora*) is represented only by one rare species in N.W. America, and *Cystoseira* is represented by one apparently rare species in New Zealand.

A plant of remarkably discontinuous distribution, which has been the subject of some discussion may be worth mentioning here—*Codium mucronatum* J. Ag. This species was originally described by Agardh in 1886, and three varieties were established, depending on the character of the mucro: var. *Tasmanicum* from Tasmania, var. *Californicum* from California, var. *Novae-zelandiae* from New Zealand. The plant was subsequently recorded from South Africa, Japan, and Cape Horn; and the var. *Novae-zelandiae* from East Australia. Cotton (1912, p. 117), described a plant from Clare Island as *C. mucronatum* var. *Atlanticum*, and stated its closest ally to be the New Zealand form; and says of it (l.c.p. 118): "This remarkable feature with regard to the distribution of *C. mucronatum* is not so much its link with the Australian forms (our other species *C. tomentosum* and *C. adhaerens* apparently occur in the Southern Hemisphere), but its isolated position in Europe. It is not known from the Mediterranean or from North Africa, and is apparently absent from the remainder of the North Atlantic." It is, however, found at various points in Ireland, Scotland, and the Isle of Man. Further he continues (l.c.p. 171): "*Codium mucronatum* var. *Atlanticum*, is even more noteworthy. So closely allied to the New Zealand form of the species as to be almost inseparable from it, and yet unknown in the Northern Hemisphere except in the British Isles, its distribution is certainly remarkable. As far as is known, it does not occur in England, but has existed in Scotland for at least seventy years, and in Ireland for upwards of a hundred." However, Setchell and Gardiner (1920, p. 171), identify *C. mucronatum* with *C. fragile* (Suring) Hariot, and state: "The mucronate tip of the utricle of this plant is a prominent specific character and is subject to extreme variation. We have studied and compared plants from a considerable number of localities ranging from Alaska to Mexico; and have come to the conclusion that species cannot be split into varieties based on that character." (i.e., of the mucro.) It is certainly true that the New Zealand specimens I have examined show considerable differences in the development of the mucro, though as yet I have not seen any of the Tasmanian type.

I hope to give the matter more detailed study later on. This, of course, still leaves the British plant with a curiously discontinuous distribution.

We have still to say a few words as to our connection with N.W. America. There are several common forms which are worthy of mention. *Codium mucronatum* J. Ag., has already been discussed. Another remarkable case is that of *Enteromorpha acanthophora*. It is known from New Zealand and Tasmania, and has recently been identified from Mexico by Setchell. It was originally described by Kuetzing from New Zealand from specimens given him by Sir J. D. Hooker. However, so little is known about the *Enteromorphas* of the Pacific generally, and they are so difficult to identify, that little stress need be laid on this case of discontinuous distribution. *Gigartina radula* again would be a sub-Antarctic species except for its occurrence in N.W. America, and *Aeodes*, hitherto regarded as an endemic New Zealand genus, has recently also been discovered there; but generally speaking there is little connection indeed between our seaweeds and those of the N.W. Pacific, which are related to the algal Flora of the Atlantic rather than to that of the South Pacific. There is, however, a slight and fairly definite connection represented by certain red seaweeds, which are apparently southern forms that have somehow crossed the tropical barrier and reached the coasts of North West America. Such species (in addition to *Aeodes* and *Gigartina radula*, already mentioned) are: *Iridaea laminarioides*, *I. cordata*, *Rhodoglossum latissimum*, *Callophyllis variegata*, *Schizoneura (phycodrys) quercifolia*, *Grateloupia pinnata*. Generally speaking, however, the tropics are an almost complete barrier to the passage of red and brown seaweeds from north and south temperate regions and *vice versa*; yet four of these species belong to our sub-Antarctic list. We may sum up by saying that the phytogeographic relationships of the New Zealand algal region are chiefly with Australia and through Australia to some slight extent with the Indian and South Atlantic Oceans. There is a small sub-Antarctic element, and a still smaller North Pacific one. A curious case is *Caulacanthus spinellus*, which is known only from Juan Fernandez, Easter Island, and New Zealand.

For the sake of students and investigators generally reference may be made to one or two of the problems confronting the New Zealand algologist. The recent discovery by Kylin, Sauvageau, and others, of a sexual generation in the European Laminarians, makes it certain that similar discoveries will in the future be made in respect of our three large Laminarians, *Macrocystis*, *Lessonia*, and *Ecklonia*. There can be no question of the closeness of the relationship of these three genera. They represent the maximum of complexity of vegetative structure in any group of Algae. The occurrence in all of them of conducting strands, sieve-tubes (trumpet-hyphae), etc., places them at the head of the brown algae; but no gametophyte is known in these three genera. Doubtless it is minute and exceedingly difficult to obtain. Probably the sexual generation is only to be obtained by cultivation in an aquarium, for the sporophytes are all large seaweeds, whose cultivation in the open would be difficult. Perhaps the only hope of dealing successfully with them would be in

a properly equipped marine biological station, and this we do not at present possess in New Zealand. It is hoped that some institution of the kind may soon be developed here; and I believe Professor Kirk contemplates the establishment of such a station at Island Bay. There would be no better place in the world for the study of the alternation of generation in these huge Laminarians, for *Lessonia*, *Macrocystis*, and *Ecklonia* all abound there. In the genus *Lessonia* (though not in the New Zealand species), huge tree-like form occur; *Macrocystis* is the longest seaweed in the world, often attaining a length of much over a hundred feet, and *Ecklonia*, though much smaller, is a comparative giant as compared with most other algae. On the other hand, it is possible that in contrast with these huge sporophytes the gametophyte consists of a few microscopic cells bearing the sexual organs.

Though the Laminariaceae have pride of place amongst the brown seaweeds, and present the most pressing problems for investigation, some of the other Phaeophyceae are in urgent need of further and more detailed examination. The strange plant of south temperate seas, *Splachnidium rugosum* (L) Grev. is still a puzzle. By the earlier algologists it was unhesitatingly placed in the Fucaceae. However, in 1892 a special order was constituted for it by Miss M. Mitchell and Miss F. Whiting, who believed that they had proved that the conceptacles contained zoospores and not oospheres as had previously been supposed. I was fortunate enough shortly afterwards (1893, p. 288) to see these zoospores (if zoospores they be and not isogamous gametes) in free motion outside the conceptacles. The same investigators also found a remarkable initial cell at the apex of each branch and at the base of each conceptacle. Later Miss M. Roe (1916, p. 400) found it preferable to retain the plant among the Fucaceae, regarding it as an intermediate between that family and the Laminariaceae. In 1920, Dr. Skottsberg investigated the plant and came to quite other conclusions (1920, pp. 277-287).

In order to explain his results, some account must be given of the general somatic structure in certain groups of the Phaeophyceae. In the Ectocarpaceae we have much branched filaments, consisting of single rows of cells. When we have these interwoven into ropes we get the cable type. This occurs in New Zealand in *Chordaria* and in *Mesogloia* (if the last named is really found here). Then in the Fucaceae we have the parenchymatous type, and further in all Laminarians trumpet-hyphae are present. Now Miss Mitchell and Miss Whiting saw in *Splachnidium* an alga of the parenchymatous type with zoospores in conceptacles. Skottsberg re-examining the plant in 1920, finds the thallus filamentous and pseudoparenchymatous; and feels justified in regarding it as of a Chordariaceous type. In *Chordaria* the ultimate ramuli bear the reproductive organs on their surface, and therefore *Splachnidium* is quite unique in the group—if it should be retained here—in possessing conceptacles.

Now a word or two about the so-called initial cells. These have not been seen to divide, nor do they in any way appear to be connected with the rest of the plant. Dr. Skottsberg regards them—and appar-

ently with good reason—as parasitic, and perhaps belonging to the genus *Codiolium*. I certainly have seen in the gelatinous interior of *Splachnidium* wandering unicellular organisms which might well be the zoospores of a *Codiolium*. Dr. Skottsberg thus concludes his paper: “*Splachnidium* is quite a unique type, still I believe there are reasons to regard it as representing a branch of the Chordariaceae, perhaps a higher stage. I do not find sufficient grounds for suppressing the order Splachnidiaceae, which from a taxonomic view is well circumscribed. There is no evidence that *Splachnidium* is intermediate between Chordariaceae and any other order.”

Here then are several problems for the student. (1.) What is the growing point or growing area of *Splachnidium*? (2.) Are the reproductive organs zoospores or isogametes? (3.) What is the so-called initial cell? (4.) How do the conceptacles develop?

A second fucoid to which I wish to call special attention is *Notheia anomala* Bail et Harv. This is a parasite confined to Australasian seas, and is limited in its distribution by the distribution of its host *Hormosira Banksii*. Considerable attention has been paid to it by various writers, but not all the literature is at present available in New Zealand. The latest investigator is Miss May M. Williams (Proc. Linn. Soc. N.S.W. 48, 1923). Oogonia, or what appear to be oogonia, have long been known in this curious little parasite; but no antheridia have been seen. Miss Williams now suggests that reproduction is by means of parthenogenetic eggs; but the cytology has not been investigated, and it will now be necessary to ascertain whether the chromosomes undergo reduction. This is another problem for the New Zealand student (v. G. Murray, 1895, p. 42).

Another genus of the Fucaceae which requires much closer investigation than it has yet received is *Xiphophora* (*Fucodium*). There is still much unknown detail in its methods of reproduction. As the whole question of the alternation of generations amongst the Fucaceae is as yet a matter of debate, it is quite possible that fundamental evidence for one or other of the theories in vogue might be obtained from the study of the life history of some of our species. *Landsburgia* and *Marginaria* are other genera requiring fuller examination.

Of the Florideae or the Chlorophyceae I propose to say nothing here. Doubtless there are many problems presented by them, but they are not so obvious and outstanding as in the Phaeophyceae.

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## The Polyporaceae of New Zealand.

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(Plates 21-24.)

UNDER the sub-class Hymenomycetes of the Basidiomycetes occur a natural group of Fungi (the Polyporaceae) characterised in that the hymenium lines hollow tubes or pits on the (usually) ventral surface of the fructification. But as to whether this group constitutes an order, family or tribe of the Hymenomycetes, no unanimity of opinion exists. A brief outline of several of the classifications published, will illustrate these differences of opinions held by different Mycologists.

The first definite classification published on the group was that of Fries (15), in which the known Polypores of that period were arranged in sequence. This work was established as the starting-point of modern nomenclature in the Hymenomycetes, at the Nomenclature Conference, held at Brussels in 1910. Papers published prior to 1821, are therefore only of historical interest, so need not be further referred to.

Fries in 1821 (15, vol. 1) divided the Polyporaceae into two genera, *Daedalea* and *Polyporus*. The latter was again divided into the three sub-genera *Favolus*, *Microporus* and *Polysticta*; and each sub-genus was further subdivided into the following five tribes:—

*Mesopus*—pileus centrally stipitate.

*Pleuropus*—pileus laterally stipitate.

*Merisma*—pilei imbricated, laterally stipitate and branched.

*Apus*—pilei dimidiate sessile or effused.

*Resupinatus*—resupinate forms.

On the consistency of the tubes, each tribe was further split into the sections *Carnosi*, *Sub-carnosi*, *Suberosi*, *Sub-suberosi*, etc.

In 1828 (16, p. 44) Fries recognized *Favolus* as a distinct genus.

In 1836 (17) he separated the genus *Trametes* from *Daedalea* as a distinct genus and recognized *Cyclomyces* and *Hexagonia* as valid genera.

In 1838 (18) he further subdivided the sessile species on the nature of the upper surface of the pileus and longevity of the plant into:—

*Anodermei*—without cuticle, fleshy, annual.

*Placodermei*—hard crust, perennial.

*Inodermei*—thin fibrous cuticle, biennial.

In 1851 (19) he divided the genus *Polyporus* into three sub-genera:—

*Eupolyporus*—annual, fleshy, tough species.

*Fomes*—perennial species with stratose tubes.

*Poria*—resupinate forms.

and separated *Polystictus* as a distinct genus on account of the coriaceous pileus, fibrous cuticle and homogeneous hymenium.

Thus in all his publications, Fries recognizes only seven genera, namely *Cyclomyces*, *Daedalea*, *Favolus*, *Hexagonia*, *Polyporus*, *Polystictus* and *Trametes*.

A related group of fungi, containing plants with the hymenium lining tubes, but differing in the nature of the context, evanescent nature and different development was in 1821 (15) separated by Fries as a distinct family, the Boletaceae.

Gillet (20) recognized all those genera proposed by Fries save *Polystictus*, and in addition erected the genera *Fomes*, *Merisma* and *Physisporus* to contain woody perennial forms, branched stipitate forms and resupinate forms respectively.

Quelet (31) raised the eleven divisions of *Polyporus* outlined by Fries into genera, eleven in all. The other Friesian genera were retained without alteration.

Saccardo (33) followed the arrangement proposed by Fries.

The next important classification to appear was that in the *Natuerlichen Pflanzenfamilien* (22), in which the sub-class Hymenomyces was divided by Hennings into six orders, one being the Polyporaceae, containing the tribes Merulieae, Polyporeae, Fistulinae, and Boleteae. Twelve genera were included in the Polyporeae, including *Lenzites*, included by earlier workers in the Agaricaceae.

In 1907-1908, Murill (28) published a classification of the North American Polyporaceae. In this he considered no less than seventy-eight genera, placed under four tribes Porieae, Polyporeae, Fomiteae and Daedaleae. This large number of genera necessitated his considering characters not likely to be regarded as being of generic value by other workers, as colour and texture of the context and pores, colour of the spores, and the like.

The most recent classification to date is that of Rea (32). Under the order Aphyllophorales (sub-order Porohydneae) are placed the families Polyporaceae, Polystictaceae, Meruliaceae, Fistulinaceae, Hydnaceae, Thelephoraceae and Cyphellaceae. The Polyporaceae and Polystictaceae each contain five genera, the former *Polyporus*, *Sistotrema*, *Fomes*, *Ganoderma* and *Poria*; the latter *Polystictus*, *Irpex*, *Lenzites*, *Trametes* and *Daedalea*. The Boletaceae is placed under the sub-order Boletineae of the order Agaricales.

When these diverse classifications are considered it becomes obvious that the difficulty confronting the student is to decide which is the most suitable. For all have their advantages, and their disadvantages. The tendency on the one hand is to retain few genera, but to group these under numerous families—in other words, to show that their relationships are distant, not close; on the other hand to erect numerous genera on slight and often inconstant characters, but to maintain these under small groups, as tribes and the like. Another disadvantage of certain of the modern classifications, is their complicated nature; for when complicated they tend to defeat the chief object of the systematist—to present the species of his region in such a manner that they shall be readily known.

After working over the New Zealand material, and abundant specimens from abroad, the writer is of the opinion that it is not practicable to maintain more genera than were accepted by Fries and certain other workers of his period. For it appears clear, to the writer at least, that Fries had already used all characters that may be considered of generic value; and a further multiplication of genera based on insufficient constancy of characters would only lead to confusion.

The genera present in New Zealand, the writer would arrange under the two tribes Polyporeae and Merulieae. These he would place under the family Polyporaceae, in turn placed under the order Polyporales, together with the Boletaceae. This arrangement may yet have to be modified, when the structure and development of the Boletaceae are more fully studied. Meanwhile the writer believes this family should be grouped with the Polyporaceae under the same order, on account of the fact that, in both, the hymenium lines definite tubes on the ventral surface of the pileus.

#### GENERIC AND SPECIFIC CHARACTERS.

Earlier workers used as a basis for classification, such characters as were readily noticeable, as the configuration of the lower surface of the pileus (whether gill-like, daedaloid, irpiciform or poroid), nature of the context, whether woody, coriaceous, fleshy or gelatinous, nature of the surface of the pileus, whether with or without a crust, hard or soft, smooth or zoned, etc.; whether the tubes formed a solitary layer or were in strata. These characters were for the most part fixed upon first by Fries, and accepted completely or in part by later workers.

Certain later workers have contended that certain of these genera (as *Fomes*, *Polyporus*) were too large, and contained too many species, and have attempted to modify the existing arrangement in various ways. One of the first to engage in such work was Quelet (31), who raised to genera, such sections of *Polyporus* as Fries had previously delimited. Others, working on colour and nature of the context, etc., colour and surface markings of the spores, have split two or three of the original genera into many—the climax having been reached by Murill (28) who recognized no less than 78 genera. Karsten (24), Patouillard (30), and more recently Lazaro (25) have also erected many genera on similar characters. It is significant that although several have been engaged in erecting numerous genera, few of these have been accepted by others engaged in similar work. Some idea as to the confusion this class of work has introduced into the literature, may be gained by a perusal of the synonymic list under the genus *Polyporus*, where almost 100 generic synonyms are listed.

The reason why close splitting of genera of the Polyporaceae cannot be adopted lies in the fact that so few characters are constant in this group. For example, with species typically stipitate, the stipe may be lateral or absent, or the plant may even be resupinate. The crust on the surface (used as a group character by certain work-

ers) may be strongly developed or wanting from different plants of the same collection.

Of recent years some attention has been paid to such microscopic characters as the colour of the spores, the nature of their surface markings, presence or absence of setae in the hymenium, and even the nature of the hyphae of which the pileus is composed.

The spores are certainly constant in all species examined by the writer, especially in colour and surface markings, and serve as admirable specific characters. But unfortunately in the majority of species, the spores are hyaline and smooth, being usually so regularly of a similar type as to be of little value generically; and so many plants are known in which they have not been found, as to invalidate their use for generic delimitation. Further, when spores are scanty in a specimen (usually the case with hyaline-spored species, irrespective of genera), when found they cannot be considered as belonging to that species, unless found attached to basidia. And if so found, it is often possible they may be immature, when—even if belonging to a rough-spored species—they may appear smooth. Many erroneous spore records have been based on descriptions drawn up of spores of *Hyphomycetes* growing on old pilei; hence the need for caution in the use of such a character.

Cystidia on the whole are quite useful specific characters, but as not infrequently they may be present or absent in different plants of the same collection (e.g., *Fomes robustus*) it is evident they cannot be considered of generic import.

Examples showing the confusion which has arisen through trying to maintain certain genera are numerous—one excellent illustration being the so-called genus *Polystictus*. Fries separated it from *Polyporus* because the pileus was coriaceous, the cuticle fibrous and the pileus heterogenous—possibly quite sound characters when the few European species he was dealing with are considered, but worthless when applied to the number now known. Rea (32) goes to the extent of separating this and other genera as the family *Polystictaceae*, separated from the *Polyporaceae* because the former was supposed to possess a homogeneous hymenium, as opposed to the heterogeneous hymenium of the latter. Other workers have attempted to show that the genus may be segregated by the hairy surface of the pileus, or its sterile margin. But all these conditions occur equally with species placed by workers (including Fries) in *Polyporus*, it is evident that *Polystictus* cannot exist as a genus, or even as a section of *Polyporus*.

Probably the idea (originating with Fries) of splitting genera into named sections has been in part responsible for the flood of "new genera" with which modern literature dealing with the *Polyporaceae* has been inundated. This serves to bring related species together, provided the correct group characters are chosen, but the characters used too often cannot be considered as being of generic value, owing to their variability. Fries, presumably, was quite aware of this fact, otherwise he probably would have erected his sections into genera.

## KEY TO THE GENERA.

POLYPORACEAE: Pileus annual or perennial; stipitate, sessile or resupinate; woody, coriaceous or fleshy. Hymenium lining the interior of tubes, shallow pores, or anastomosing plates; tubes sometimes toothed; basidia unicellular, apically sterigmate, tetrasporous; spores continuous, coloured or hyaline, rough or smooth.

Tribe Polyporeae: Hymenium lining coherent tubes, sometimes toothed. Receptacle pileate.

Tubes entire.

Tubes in strata .... 1. *Fomes*.

Tubes not in strata.

Tubes at proximal ends even. .... 2. *Polyporus*.

Tubes at proximal ends sunk different depths into context.... 3. *Trametes*.

Tubes torn into teeth. .... 4. *Irpex*.

Receptacle resupinate.

Tubes in strata } .... 5. *Poria*.

Tubes not in strata } ....

Tribe Merulieae: Hymenium lining fold-like plates anastomosing frequently to form shallow pores

6. *Merulius*.

1.—The Genus *Fomes*.

1. \**Fomes* Gillet, *Champ. Fr.*, vol. 1, p. 682, 1878.

*Ganoderma* Karst., *Rev. Myc.*, vol. 3, p. 17, 1881.

*Fomitopsis* Karst., l.c., p. 18.

*Xylophilus* Karst., *Hattsv.*, vol. 2, p. 69, 1882.

*Placodes* Quel., *Ench. Fung.*, p. 170, 1886.

*Phellinus* Quel., l.c., p. 172.

*Mucronoporus* Ell. et. Ev., *Jour. Myc.*, vol. 5, p. 28, 1889.

*Elfvigia* Karst., *Finn. Basidsv.*, p. 333, 1889.

*Heterobasidion* Bref., *Unters. Gesammt. Myk.*, vol. 8, p. 154, 1889.

*Ungulina* Pat., *Cat. rais. Pl. cell. Tunisie*, p. 48, 1897.

*Pyropolyporus* Murr., *Bull. Torr. Bot. Cl.*, vol. 30, p. 109, 1903.

*Globifomes* Murr., *Bull. Torr. Bot. Cl.*, vol. 31, p. 424, 1904.

*Nigrofomes* Murr., l.c., p. 425.

*Fomitella* Murr., *Bull. Torr. Bot. Cl.*, vol. 32, p. 365, 1905.

*Amauroderma* Murr., l.c., p. 366.

*Porodaedalea* Murr., l.c., p. 367.

*Whitfordia* Murr., *Bull. Torr. Bot. Cl.*, vol. 35, p. 47, 1908.

*Hemidiscia* Laz., *Polip. Fl. Espan.*, p. 82, 1917.

*Pseudofomes* Laz., l.c., p. 87.

*Friesia* Laz., l.c., p. 92.

*Ungularia* Laz., l.c., p. 110.

*Mensularia* Laz., l.c., p. 124.

*Scalaria* Laz., l.c., p. 127.

*Boudiera* Laz., l.c., p. 150.

\**Fomes* was not used as a generic name by Fries, though the genus is credited to him in most publications. In 1851 (19) he divided *Polyporus* into the sub-genera *Eupolyporus* and *Fomes*, citing species accordingly as *Polyporus* (*Fomes*). . . . The sub-genus was raised to generic rank subsequently by Gillet.

Pileus perennial; woody or corky; stipitate, sessile or resupinate; appanate, unguulate or subglobose; exterior anoderm or encrusted, sometimes varnished; context white or coloured; tubes strato-se; cystidia present or wanting; spores hyaline or coloured, rough or smooth, continuous.

Habitat: On wood; parasitic or saprophytic.

Distribution: World-wide.

The genus is characterized by the strato-se tubes and usual woody habit. In most species the strato-se tube are so noticeable as readily to place them in the correct genus; in others—especially in certain tropical species where growth is continuous—they are often poorly defined; and in certain rare cases, as in *Polyporus gilvus* and *P. Braunii*, they occur so seldom as to warrant their appearance being accidental, and therefore justify the placing of such under *Polyporus*.

All New Zealand species are sessile, though a few have lateral stipe-like projections suggesting stipes, but elsewhere occur species with definite central stems. With us, all occur on wood, but in the tropics a few terrestrial forms are known. In the related genus *Poria* are grouped plants with strato-se and non-strato-se pores. Doubtless most of the strato-se "species" are resupinate forms of *Fomes* (and indeed many have already been shown to belong to this genus); but until they have been connected with their pileate forms, they are as a matter of convenience placed under this genus.

*Fomes* has been split into numerous genera by different workers, as the synonymy shows. Most have been ignored by the majority of systematists, but a few have within recent years, come into more or less general use and consequently require further discussion before being dismissed.

*Ganoderma* was erected in 1881 by Karsten (23) as a monotypic genus containing the species *G. lucida*, characterized by the laccate pileus and stipe. Later, on the same characters Quelet erected his genus *Placodes*. Patouillard (29) extended *Ganoderma* to include all species possessing coloured spores, shining, laccate pilei and adhering, strato-se, or non-strato-se tubes. It is this last character (the strato-se or non-strato-se tubes) which has caused so much confusion in literature, for naturally it breaks down the only possible division between *Polyporus* and *Fomes*. Later Patouillard (30) separated the species of *Polyporus* and *Fomes* possessing hard, coloured context and divided them into four genera, on the following characters:—

Plants with laccate crust.					
Spores coloured, truncate ....	....	....	....	....	<i>Ganoderma</i> .
Spores hyaline ....	....	....	....	....	<i>Ungulina</i> .
Plants without a laccate crust.					
Spores coloured ....	....	....	....	....	<i>Xanthochrous</i> .
Spores hyaline ....	....	....	....	....	<i>Phellinus</i> .

Now as in New Zealand in the same species may occur plants with and without this laccate crust, it is obvious that this character cannot be considered as possessing generic value; and as has been shown, spore characters in a group where they are so frequently wanting, cannot be used generically.

*Mucronoporus* was erected for species of *Polyporus*, *Fomes* and *Poria* possessing strongly developed coloured setae in the hymenium. But these structures may be present or absent in different plants of the same species, so cannot be used generically.

Murrill's genera were for the most part erected on such characters as colour of the context and spores, presence or absence of a stipe, and the like; characters, as has been shown, that are of no value generically. Lazaro (25) appears to have given new generic names to sections already previously named by Karsten, Patouillard and Murrill.

#### STRUCTURE OF THE MATURE PLANT.

As an example, the abundant *Fomes hemitephrus* is chosen, as it may readily be found (in Wellington district at least) throughout the year on fallen beech trunks in the forest; and in addition well illustrates certain peculiarities characteristic of the genus.

The fruit body, termed herein the pileus (but known also as sporophore, receptacle or hymenophore) consists of three distinct structures, the cuticle, context and tubes. It is usually applanate in shape, and is attached to the substratum by a broad, thickened lateral portion often prolonged in certain species into a stem-like structure (c.f. *F. subtornatus*). The surface (cuticle) is covered with a very hard crust, brown or black in colour and appearing like pitch when cut into. It may be even, but more often is zoned. In other species the crust is replaced by a thin, soft and fibrous cuticle. In old specimens the crust is often rimose (broken into small areas by numerous crevices). Beneath the crust lies the flesh, or context as it is here termed (trama of certain workers; medulla of de Bary). In fresh plants it is often snow-white, but in herbarium specimens it ranges from pallid ochre to isabelline. It is usually coloured tawny orange immediately beneath the crust, and on this account the species may be readily recognised. The context is composed of thick-walled, interwoven hyphae.

Attached to the context, on the lower surface of the pileus, lie the strata of tubes, their number depending on the age of the plant. Each tube is in reality a cylindrical cavity in the tissue of the context, which is consequently modified by its presence, especially in the arrangement of the hyphae, and is lined with the hymenium, consisting of basidia and paraphyses. The tubes are so closely compacted as to give the impression that they are in reality separate cylinders; but as it is not possible to dissect them out, their true nature is evident. In certain other genera, as *Boletus* and *Fistulina*, they really are separable from one another, hence the acceptance for the universally used term tube. The basidia are small cylindrical or clavate structures, bearing at their apices four small sterigmata on which in turn are borne the four elliptical, hyaline, smooth spores. In this paper the term hymenium is limited to the layer of basidia, paraphyses and sub-hymenial tissue underlying them; but in most the term is somewhat loosely applied to the whole of the pore strata.

A fresh stratum is formed each growth period, which with this species (in New Zealand at least) occurs twice a year. A white

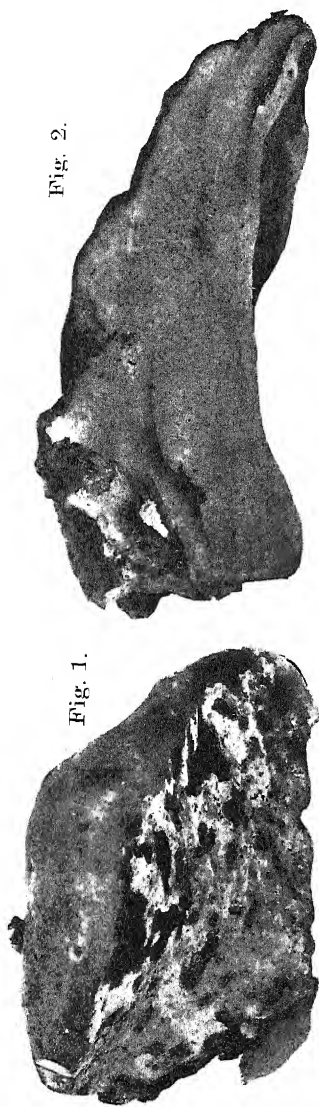


Fig. 2.



Fig. 4.



Fig. 3.

FIG. 1.—*Fomes hemitephrus*, x  $\frac{1}{3}$ . Ungulate form without sulcate zones on the surface, showing in addition imperfect development of tube strata on lower surface. Probably the form determined as *F. homothecus* by Lloyd.  
FIG. 2.—*F. hemitephrus*, x  $\frac{1}{2}$ . Section of typical applanate form showing the context, numerous pore strata and crust.  
FIG. 3.—*F. hemitephrus*, x  $\frac{1}{3}$ . Subresupinate form showing the sulcate surface. Plant was growing in exactly the position photographed.  
FIG. 4.—*F. hemitephrus*, x  $\frac{1}{2}$ . Ventral surface showing development of a second pileus on the surface of the old ventral surface.

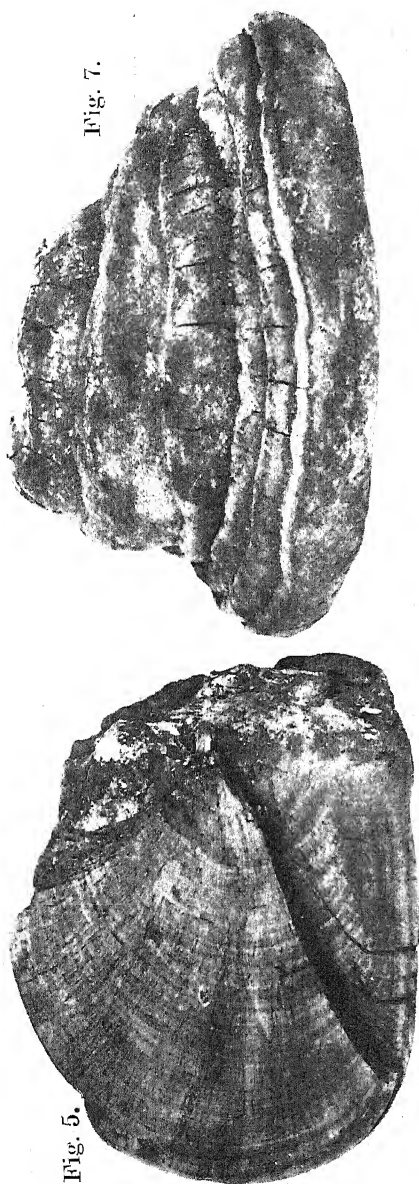


Fig. 5.

Fig. 7.



Fig. 6.

Fig. 8.

- FIG. 5.—*Fonces robustus*, x  $1/3$ . Subglobose form not uncommon in New Zealand. Note the strong development of both radial and concentric zones in the context.
- FIG. 6.—*F. robustus*, x  $1/2$ . Small, subglobose, usually resupinate form without a crust.
- FIG. 7.—*F. robustus*, x  $1/3$ . Ungulate form not uncommon in New Zealand. Note the strongly sulcate surface and rimose crust. Contrast with Fig. 5.
- FIG. 8.—*F. robustus*,  $1/2$ . Subresupinate form on *Cassinia leptophylla*. Note pileus development on left.

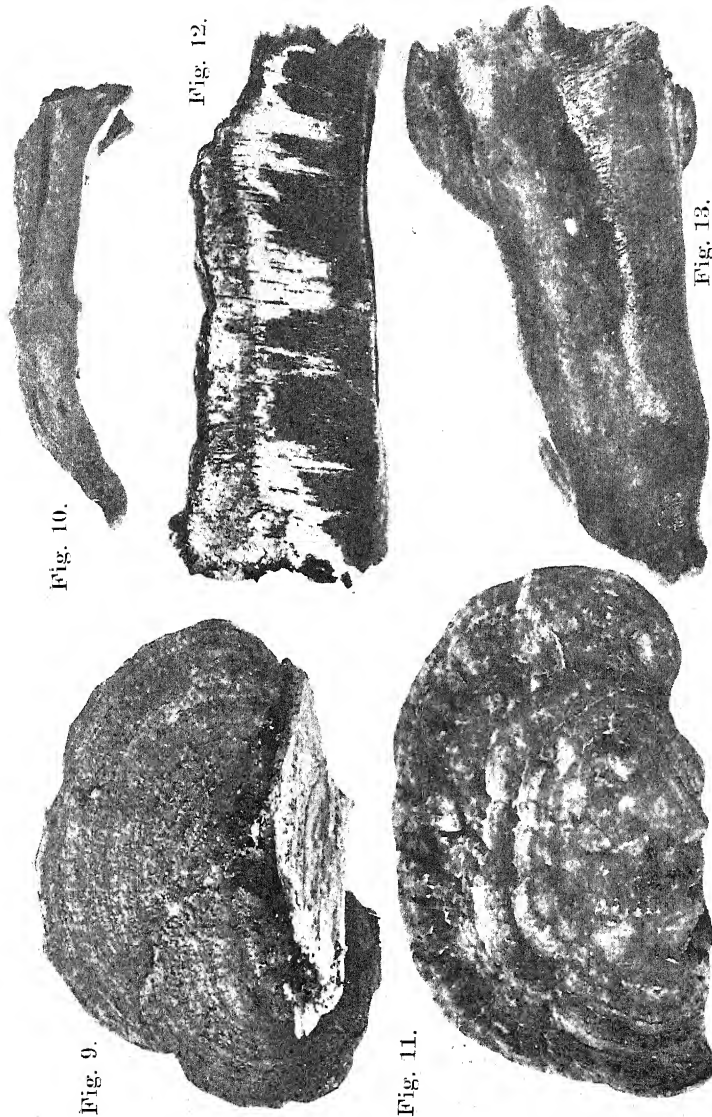


FIG. 9.—*Fomes zelandicus*, x  $1\frac{1}{2}$ . Applanate form with zoned surface but no distinct crust.  
 FIG. 10.—*F. zelandicus*, x  $1\frac{1}{2}$ . Section through pileus showing the absence of a crust, thin context and obscure strata.  
 FIG. 11.—*Fomes applanatus*, x  $1\frac{1}{2}$ . Typical plant, with a strongly sulcate zoned, rugulose and tuberculate surface.  
 FIG. 12.—*Fomes australis*, x  $1\frac{1}{3}$ . Section through the pileus of the applanate form. Note strong development of tubes, and thick crust. Specimen infected with a parasitic fungus, hence discoloured nature of the context and tube strata.  
 FIG. 13.—*F. australis*, x  $1\frac{1}{3}$ . Section through sub-ungulate form on *Sclit.*

Fig. 16.

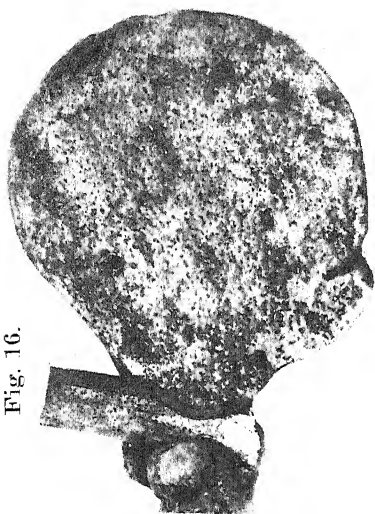


Fig. 14.



Fig. 15.

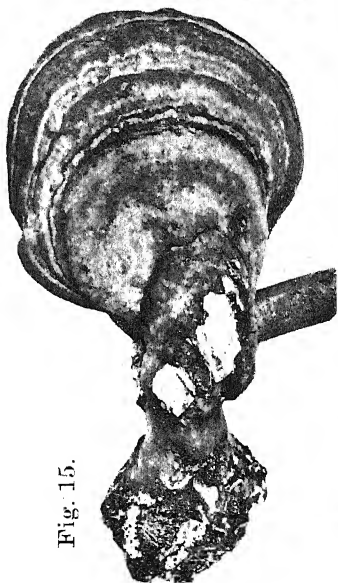


Fig. 17.

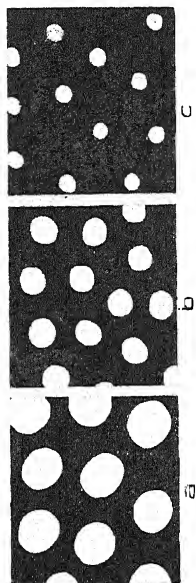


FIG. 14.—*Fomes subtoratus*, x 1/2. Section through pileus of applanate form showing thick crust and zones of crust in context. Plant attacked at point of attachment by a parasitic fungus.

FIG. 15.—*F. subtoratus*, natural size. Young plant showing lateral stipe-like point of attachment.

FIG. 16.—*F. subtoratus*, natural size. Ventral surface of Fig. 15, showing the pitted nature of the tube layer, characteristic of this species.

FIG. 17.—Diagram of the tubes of related species, x 35. (a) *F. australis*; (b) *F. applanatus*; (c) *F. subtoratus*. Note that in a and b the walls are about the same thickness, but the tubes vary considerably in diameter; whereas in c the walls are much thicker and the tubes of smaller diameter. Drawn with a camera lucida from actual sections taken from immediately beneath the tube mouths.

All photographs conjointly by H. Drake and the writer.

mycelium grows from the margins, and sometimes also from the central portions of the ventral surface of the pileus, and covers the preceding tube layer. In this tubes rapidly appear, and shortly spore discharge occurs, spores being liberated over a short period in such numbers as to colour white, underlying branches, pilei and the like. In other species spore discharge differs considerably. For example White (34) has shown that with *F. applanatus* spore discharge is continuous over a period of six months; Faull (14) has shown that *F. fomentarius* develops a new stratum of tubes in the autumn but delays production and liberation of spores until the spring; and that each stratum may produce spores for four years in succession.

After discharge, the ventral surface often becomes discoloured, frequently black. As many as 20 strata have been counted in one specimen, so obviously the plant must live for a considerable period, in the specimen under consideration at least ten years.

The species is a saprophyte, occurring on fallen (or dead standing) logs in beech forests. But other species of the genus present in New Zealand are of considerable economic importance, as they attack and destroy many of our most valuable timber trees. It is hoped, working in collaboration with Officers of the State Forest Service, these timber rots will be thoroughly investigated; but as such an investigation is not possible until our species are known, the object of the present paper becomes obvious.

In working over the species in his herbarium, the writer found it was a simple matter to arrange specifically the plants contained therein; but he found it was much more difficult to apply names to those species on account of the chaotic nature of the literature. In consequence he has had to obtain much material from abroad for comparative purposes, and to call on the aid of those workers abroad who have familiarized themselves with the plants of their region, for comparisons of New Zealand material with species occurring elsewhere.

For aid in these particulars the writer is indebted to the following:—

The late Dr. C. G. Lloyd, Cincinnati, Ohio; Dr. J. R. Weir, Mycological Exchange, Dept. of Agriculture, Washington, U.S.A.; Dr. J. B. Cleland, The University, Adelaide, South Australia; Miss E. M. Wakefield, Royal Herbarium, Kew, England; Mr. E. W. Mason, Imperial Bureau of Mycology, Kew, England; the late Dr. N. Patouillard, France; Abbe G. Bresadola, Trento, Italy; and for collections of New Zealand material, those individuals cited under the different species.

#### KEY TO THE SPECIES.

Context white or light coloured	....	....	....	1. <i>F. hemitephrus</i> .
Context ferruginous or fulvous; cystidia present; spores hyaline and smooth.				
Surface with a definite hard crust	....	....	....	2. <i>F. robustus</i> .
Surface without a crust	....	....	....	3. <i>F. zelandicus</i> .

Context chocolate or umber; cystidia absent; spores coloured and verruculose.

Walls of tubes thin, about 0.1 mm.

Tubes about 0.18 mm. diam. .... 4. *F. applanatus*.

Tubes about 0.25-0.3 mm. diam. .... 5. *F. australis*.

Walls of tubes thick, about 0.2 mm. .... 6. *F. subornatus*.

#### DISTRIBUTION.

*F. applanatus* N.Z., Aus., Europe, N. & S. America, Asia.

*F. australis* N.Z., Aus., Tropical America and Asia.

*F. hemitephrus* N.Z., Aus.

*F. robustus* N.Z., Aus., Europe, N. America.

*F. subornatus* N.Z., East Indies.

*F. zelandicus* N.Z. ? Java.

The distribution of the species is interesting, for with the possible exception of *F. zelandicus*, not one is endemic, yet most occur on endemic hosts.

#### 1. *Fomes hemitephrus* (Berkeley) Cooke, *Grevillea*, vol. 14, p. 21, 1885. (Figs. 1-4).

*Polyporus hemitephrus* Berk., *Fl. N.Z.*, vol. 2, p. 179, 1855.

*P. hemitrephius* Berk., *Hdbk. N.Z. Fl.*, p. 608, 1864.

*F. martius* Lloyd, *Syn. Gen. Fomes*, p. 214, 1915.

*F. cuneatus* Lloyd, *l.c.*, p. 217.

Pileus applanate, seldom ungulate, sometimes resupinate, attached by a broad base, 3-14 x 3-25 x 1-9\* c.m.; surface covered with a definite hard and firm crust, at first reddish-brown, becoming black and shining, especially when cut, 0.25-2 mm. thick, bay brown, umber or black, zoned, often tuberculate, in old plants frequently rimose; context firm and tough, white to isabelline, frequently zoned, tawny orange immediately beneath the crust; ventral surface plane or irregular, often with a posterior decurrent spur, margin sometimes incurved, white when young, becoming isabelline, brown or black; tubes distinctly strato-se, colour of the context, mouths minute, about 5 to mm.; spores hyaline, elliptical, smooth, 3-6 x 2-3 mm.†; setae absent.

Habitat: On fallen and dead standing trunks of *Nothofagus* spp. (chiefly *N. fusca* (Hook. f.) Oerst.).

York Bay, Wellington; Sept. 1921; June 1922; Apl. 1926; Jan. 1927; *G.H.C.*

Day's Bay, Wgton; Nov. 1926; *D. W. McKenzie!*

Paekakariki, Wgton.; June 1923; *J. C. Neill!*

Longwood Range, Southland, 1200 m.; Nov. 1924; *J. C. Neill!*

Dunedin, Otago; Nov. 1926; *Messrs. Scott-Thomson and Simpson!*

\*To standardize descriptions, the writer has followed Murrill (27) and other recent workers in using figures which represent length, breadth and thickness respectively. In all, the greatest part of the pileus is considered in the measurement, including, when present, the lateral stipe-like point of attachment. Generally, however, plants vary to such an extent that measurements can convey only approximately any idea as to size.

†The spore measurements given are based on spores attached to basidia. Spores are rare in herbarium specimens (of this species) so that these measurements may possibly have been based on immature spores, though agreeing with spores obtained from spore prints.

Distribution: Australia; New Zealand.

Common in beech forests in Wellington Province. It apparently does not attack living trees, but further work is necessary before this can be determined with certainty.

A highly variable species, characterized by the pallid isabelline colour of the context, tubes and ventral surface; definite crust with underlying tawny orange coloured context; distinctly stratose tubes, hyaline, smooth spores, and absence of setae.

The shape varies from appanate to ungulate. The surface may be anoderm (especially in young plants) or covered with a reddish-brown or black firm and hard crust, which may be zoned, tuberculate or rimose. The ventral surface also varies considerably. In young and vigorously growing plants it is even and usually white (or isabelline in herbarium specimens). In old plants, as the vigour of the plant declines, the strata may not extend over the whole surface, when the fresh portion contrasts strongly with the old and discoloured surface. Often small "islands" only develop, and as the plant ages, this gives rise to several regions of strata on the same pileus.

*F. martius* Lloyd does not appear to differ in any particular; *F. cuneatus* Lloyd is an ungulate form (not uncommon in the collections at hand); consequently both are considered synonyms of *F. hemitephrus*, especially as they occur on the same host genus.

Lloyd has recorded both *F. hornodermus* and *F. pinicola* as occurring in New Zealand (26, p. 214, 219); but as neither has been found by the writer, nor been recorded as being present in New Zealand by any other worker, the writer believes them to be based on misdeterminations of *F. hemitephrus*.

## 2. *Fomes robustus* Karsten, *Krit. Ofvers. Finl. Basidsv.*, p. 467, 1889. (Figs. 5-8.)

*Pyropolyporus Calkinsii* Murr., *Bull. Torr. Bot. Cl.*, vol. 30, p. 113, 1903. (teste Bresadola).

*Fomitiporia dryophila* Murr., *N. Am. Fl.*, vol. 9, p. 8, 1907 (teste Bresadola).

*F. tsugina* Murr., *l.c.*, p. 9. (teste Bres.).

*Pyropolyporus Bakeri* Murr., *l.c.*, p. 104, 1908. (teste Bres.).

*P. Robinsoniae* Murr., *l.c.*, p. 108. (teste Bres.).

*Fomes Hartigii* (Allesch.) Sacc. et Trav., *Syll. Fung.*, vol. 19, p. 712, 1910 (teste Bres.).

*F. setulosus* Lloyd, *Syn. Gen. Fomes*, p. 243, 1915. (teste Lloyd).

*F. squarrosus* Lloyd *l.c.*, p. 247.

*Phellinus robustus* (Karst.) Boud. et Galz., *Bull. Soc. Myc. Fr.* vol. 41, p. 188, 1925.

Pileus ungulate or subglobose, often resupinate, attached by a broad base, equal, 3-16 x 4-25 x 3-15 cm.; surface at first light fulvus and tomentose, becoming covered with a thick (1-5mm.), hard, dull black crust, usually sulcately zoned and often rimose; context bright fulvus yellow, in old specimens often approaching ferruginous, firm, hard, radially and concentrically zoned; ventral surface even, concolorous with the context; tubes distinctly stratose, mouths about 5 to

mm., concolorous, subhymenium cellular, hyaline; spores globose to subglobose, 6-8 mmm., hyaline, smooth, sparse; setae abundant, chestnut brown, ventricose, acuminate pointed.

Habitat: On living trunks of *Nothofagus fusca* (Hook. f.) Oerst.  
York Bay, Wellington; Sept. 1921; Apl. 1926; Jan. 1927;  
*G.H.C.*

Day's Bay, Wellington; Nov. 1926; *D. W. McKenzie!*  
Paekakariki, Wellington; June 1923; *J. C. Neill!*  
Rotorua, State Forest Reserve; *Unknown collector!*

On living branches of *Cassinia leptophylla* (Forst. f.) R. Br.  
Weraroa, Wellington; Mar. 1926; *H. McDonald—G.H.C.*  
White Rock Station, Featherston, Wellington; *J. Barton!*  
May 1927.

Dead *Leptospermum scoparium* Forst. branch.  
Dunedin, Otago; Oct. 1925; *Miss H. K. Dalrymple!*  
(Setae absent, but otherwise the same.)

Distribution: Britain, Europe, North America, Australia, New Zealand.

The marked ungulate, often globose shape, light fulvus coloured context, hard crust, abundant setae and subglobose, hyaline, smooth spores are the characters of the species.

The plant is not uncommon in beech forests in the Wellington Province, where it produces a serious heart-rot of *Nothofagus fusca*. The species is often confused with *F. igniarius*, which differs in the darker colour of the context, but otherwise appears to be identical. Setae are abundant in all New Zealand collections, and apparently also in most Australian plants, according to Cleland and Cheel (10), though these workers have recorded occasional collections in which few or none are present; but many European and North American collections are known in which they are consistently absent. This shows that the presence or absence of setae is of little specific significance.

The form on *Cassinia leptophylla* is responsible for the killing of numerous plants of this coastal shrub in the Weraroa and Featherston districts. Recently, in company with Mr. H. McDonald, the writer made an inspection of an area near Weraroa beach where numbers of plants had been destroyed. Penetration was effected through the crutches of the branches, which in this plant readily split apart. Here a rapid white heart rot was produced, followed by death of the plant. The pilei were secured in numbers usually near the base of dying plants, but were also numerous on dead branches lying on the ground. Most were resupinate, but a few showed scanty pileus formation. Otherwise they agreed in all particulars, especially in microscopic details, with *F. robustus*. The colour of the context of most was also the same, but in some both context and surface of the pores were darker, approaching ferruginous. These latter could be referred to light coloured forms of *F. igniarius*; but as most are typically *F. robustus* in colour, and as *F. igniarius* has not been collected in Australasia, it is considered advisable to keep this form under *F. robustus*. It is worthy of note that this colour variation occurs also in certain normal pilei of *F. robustus*.

3. **Fomes zelandicus** Cooke, *Grevillea*, vol. 8, p. 57, 1879 (Figs. 9-10.)

Pileus applanate or plane, frequently resupinate, often dimidiate, attached by a broad base, 3.14 x 5.25 x 1.4 cm.; exterior concentrically, often sulcately zoned, fulvus to umber, lighter in colour towards the thin and entire margin, hard, woody, but without a distinct crust, margin even or erenulate; context thin, 2.5 mm., fulvus to reddish-brown; tubes indistinctly stratified, stuffed, sometimes interrupted by layers of context, ferruginous or concolorous with context; ventral surface even, margin sterile, mouths concolorous, about 6 to mm., subhymenium hyaline, cellular; spores subglobose or more frequently elliptical, 3.5-5 mm., smooth, hyaline; setae abundant, acuminate, often hooked, ventricose, chestnut brown.

Habitat: Dead fallen logs of *Nothofagus* spp., *Dacrydium cupressinum* Sol., and *Podocarpus spicatus* R. Br.

Weraroa, Wellington; July 1919; G.H.C.

Wilton's Bush, Wellington; Nov. 1926; D. W. McKenzie!

Day's Bay, Wellington; Nov. 1926; D. W. McKenzie!

Ngaoi, Wellington, Nov. 1926; D. W. McKenzie!

Distribution: New Zealand, (?) Java (teste Bres. 6).

The thin applanate, often plane pileus, absence of a definite crust, thin fulvus or ferruginous context, chestnut setae and hyaline, smooth spores are the characters of the species.

Collections sent abroad have been determined as *Fomes senex* (Nees et Mont.) Fr., a plant with coloured spores; but as our plant has hyaline spores, it is evident it cannot be considered the same as *F. senex*, though agreeing in most other particulars.

Bresadola (7) lists *F. zelandicus* as a synonym of a form of *Polyporus Korthalsii* Lev.; but Lloyd (26, p. 277) states that the latter plant is in turn a synonym of *P. sideroides*. In another paper (Letter 36, p. 3, 1911) Lloyd stated that *P. sideroides* has globose, coloured spores, and is moreover stipitate, and considered that *P. Korthalsii* was merely a sessile form of this species, possessing exactly the same coloured spores. Bresadola, in a later paper (9) in discussing *F. Hochneii* Bres., and comparing it with *F. zelandicus* (which he now considered as valid) stated that the pileus of the latter is applanate, the context fulvus, pores minute, and spores absent (from the type), and contended that because they are absent they are hyaline (for it is a well-known feature of the genus that spores are sparse and often absent from plants of species possessing hyaline spores).

In view of these facts the writer considers that our plant, on account of its hyaline spores (which are abundant in one or two collections at hand) is specifically distinct from *F. senex*, and contends that it is co-specific with *F. zelandicus*, the type only of which is known, and proposes therefore to use this specific name.

Bresadola's record of the occurrence of *F. zelandicus* in Java is possibly based on *F. senex* (for spores were not found), so that there is a possibility our plant is endemic, as the type was named from New Zealand.

4. **Fomes applanatus** (Persoon) Gillet, *Champ. Fr.*, vol. 1, p. 686, 1878 (Figs. 11-17, b.).

*Boletus fomentarius* var. *applanatus* Pers., *Syn. Meth. Fung.*, p. 536, 1801.

*Polyporus applanatus* Wallr., *Fl. Crypt. Germ.*, vol. 4, p. 591, 1833; non *P. applanatus* Fr., *Epi.*, p. 465, 1838.

*P. vegetus* Fr., *Epi.*, p. 464, 1838.

*P. megaloma* Lev., *Ann. Sci. Nat.*, ser. 3, vol. 5, p. 128, 1846.

*P. leucophaeus* Mont., *Syll. Crypt.*, p. 157, 1856.

*P. incrassatus* Berk., *Jour. Linn. Soc.*, vol. 16, p. 54, 1878.

*Fomes leucophaeus* Cke., *Grev.*, vol. 14, p. 18, 1885.

*F. megaloma* Cke., *l.c.*

*Placodes applanatus* Quel., *Fl. Myc. Fr.*, vol. 1, p. 400, 1888.

*Fomes vegetus* (Fr.) Sacc., *Syll. Fung.*, vol. 6, p. 179, 1888.

*F. incrassatus* (Berk.) Sacc., *l.c.*, p. 205.

*Elfvigia applanata* Karst., *Ofvers. Finl. Basidsv.*, p. 334, 1889.

*Phaeoporus applanatus* Schroet., *Krypt. Fl. Schles.*, vol. 3, p. 490, 1889.

*Ganoderma applanatum* Pat., *Bull. Soc. Myc. Fr.*, vol. 5, p. 67, 1889.

*G. leucophaeum* Pat., *l.c.*, p. 73.

*Polyporus rubiginosus* (Schad.) Quel., *Ass. Fr.*, p. 6, 1891.

*Elfvigia lipsiensis* Murr., *Bull. Torr. Bot. Cl.*, vol. 30, p. 297, 1903.

*E. megaloma* Murr., *l.c.*, p. 300.

*Ganoderma lipsiensis* (Batsch) Atk., *Ann. Myc.*, vol. 6, p. 189, 1908.

Pileus applanate, subungulate only in young plants, seldom resupinate, attached by a small base, 5-14 x 5-20 x 4-6 cm.; surface smooth, becoming only slightly sulcate-zoned, often tuberculate, umber or bay brown, dull, sometimes colour zones present, margin thin, even or crenately lobed, not or slightly incurved, at first soft, becoming covered with thick, dull brown or black crust; context chocolate or umber brown, often zoned with layers of same nature as crust; ventral surface even, varying in colour from dingy cream to deep umber; tubes obscurely stratose, cinnamon, stuffed, about 180 mm. diam., walls about 90 mm. thick; spores elliptical or pip-shaped, apiculate, or more frequently truncate, pallid chestnut, finely verruculose, 8-9 x 5-6 mm.; setae absent.

Habitat: On trunks and fallen logs of *Podocarpus spicatus* R. Br. and *Dacrydium cupressinum* Sol.

Weraroa, Wellington; July 1919; *G.H.C.*

Paekakariki, Wellington; June 1923; *J. C. Neill!*

Wilton's Bush, Ngaio, Wellington; Nov. 1926; *D. W. McKenzie!*

Riccarton, Canterbury; Feb. 1927; *D. W. McKenzie!*

State Forest Reserve, Rotorua; *Unknown Collector!*

Distribution: Britain, Europe, Asia, North and South America, Australia, New Zealand.

The regular applanate shape, thin tube walls, hard crust, chocolate context and verruculose, often truncate, coloured spores are the characters of the species.

This and the two following species are closely related, but may be separated by the following characters:—\*

Walls of tubes 0.09-0.1 mm. thick.

Tubes 0.18-0.2 mm. diam. .... *F. applanatus.*

Tubes 0.27-0.3 mm. diam. .... *F. australis.*

Walls of tubes 0.2-0.25 mm. thick .... *F. subornatus.*

The ventral surface of the pileus of this species varies considerably in colour according to the period of the year when collected; and to the age of the plant. For it may range through all shades from dingy cream to a deep umber.

The crust, too, varies greatly; in young plants it is soft and readily cut with a knife, and is light in colour. Whereas in older plants it is hard, firm, and sometimes (though rarely) rimose. Yet on these differences several species have been erected!

The species is regularly confused in literature with the following, yet it is quite distinct, though the distinctions are principally of the nature of minor differences difficult to define, and for this reason the writer has selected the diameter of the tubes as being the most marked feature, this being about half that of the tubes of *F. australis*.

The nature of the markings on the surface of the spores has been the subject of considerable controversy in the literature dealing with this and related species. Coleman (11) as the result of a critical examination of microtome sections, differentially stained, of several species, has shown that there are two layers comprising the wall, an outer epispore and an inner endospore. He considers, "The epispore represents the primitive spore wall, and is probably comparable with the undifferentiated spore wall of such a form as *F. fomentarius*, which is very thin, and which, treated by the same methods used for *Ganoderma* spores (= *Fomes* with this type of spore, as *F. applanatus*) has shown no differentiation whatever. It consists of a hemicellulose with possibly a gum, which latter, if present, functions in attaching the spore to the surface upon which it falls. The endospore is composed of chitin and other compound or compounds. It is laid down on the inner margin of the epispore as a series of granules which later fuse to form a membrane. This thickens and develops on its outer surface spiny processes which project into the epispore at a time when

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\*Variations occur even with these characters; *F. applanatus* on the one hand approaching *F. australis* in the diameter of the tubes; on the other *F. subornatus* in the thickness of the walls. Variations are dependent in large part on the age of the plants, young specimens possessing larger tubes and thinner walls. The diagrams (Fig. 17) were drawn from average specimens of medium age (approx. 5 years). Where such variation occurs, *F. subornatus* may be recognised by the rugulose or pitted ventral surface, constant in all specimens at hand; *F. australis* by the larger size, and thicker margin (see Figs. 12, 13), characters present even in quite young plants.

the latter is still plastic. The whole endospore structure obviously functions as a sort of skeletal support to the thin and collapsible primary spore wall." If the spores are examined while fresh, they often appear quite smooth, but in herbarium specimens they regularly appear verruculose. This is due no doubt to collapse of the episporium, when the projections of the endospore become plainly visible. Probably it was because of the fact that many previous workers have examined fresh spores that they have claimed they were smooth.

5. *Fomes australis* (Fries) Cooke, *Grevillea*, vol. 14, p. 18, 1885, (Figs. 12-13, 17 a).

*Polyporus australis* Fr., *Elench Fung.*, p. 108, 1828.

*P. chilensis* Fr., *Nov. Symb.*, p. 63, 1851 (teste Bres.).

*P. Oerstedii* Fr., l.c. (teste Murrill).

*P. scansilis* Berk., *Linn. Jour. Bot.*, vol. 16, p. 56, 1878.

*Fomes scansilis* (Berk.) Sacc., *Syll. Fung.*, vol. 6, p. 165, 1888.

*F. chilensis* (Fr.) Sacc., l.c., p. 176.

*Ganoderma australe* (Fr.) Pat. *Bull. Soc. Myc. Fr.*, vol. 5, p. 71, 1889.

*Scindalma tornatum* Kuntze, *Rev. Gen.*, vol. 3, p. 517, 1898.

*Elfvigia tornata* (Pers.) Murr., *Bull. Tor. Bot. Cl.*, vol. 30, p. 297, 1903.

*Fomes oroflavus* Lloyd, *Syn. Gen. Fomes*, p. 265, 1915.

*F. galegensis* Lloyd, l.c.

*F. annularis* Lloyd, l.c., p. 268.

*F. Petchii* Lloyd, l.c.

Pileus appanate, or ungulate, irregular in size and shape, 5-30 x 10-50 x 6-20 cm.; surface even, dull, sulcately zoned, often rimose; crust hard and firm, up to 10 mm. thick, brown to black; context chocolate or umber, often zoned with layers of tissue similar to that of the crust, hard, firm, occupying about one-third of the pileus; tubes obscurely stratoe, cinnamon, often stuffed, large, 0.25-0.3 mm. diam., walls thin, about 0.1 mm., mouths even, bay brown to umber; spores 8-12 x 6-7.2 mmm., chestnut brown, frequently deeply coloured, strongly verruculose, frequently truncate; setae absent.

Habitat: On dead standing tree trunks in the forest.

Dead stump of *Coprosma lucida* Forst. f.

Weraroa, Wellington; Sept. 1919; G.H.C.

Trunk of living *Podocarpus spicatus* R. Br.

Peel Forest, Canterbury; Aug. 1921; W. K. Dallas!

Trunk of *Nothofagus Menziesii* (Hook. f.) Oerst.

Dunedin, Otago; Dec. 1926; Scott-Thomson and Simpson!

Living trunks of *Nothofagus fusca* (Hook. f.) Oerst.

Gollan's Valley, Wellington; Sept. 1921; W. D. Reid!

Day's Bay, Wellington; Nov. 1926; D. W. McKenzie!

Dead stump of *Salix babylonica* L.

Spring Creek, Blenheim, Marlborough; Dec. 1926; G.H.C.

Dead stump of *Acacia dealbata* Link.

Dunedin, Otago; Feb. 1923; *R. B. Tennent!*

Var. *oroflavus* (Lloyd) n. comb.

*Fomes oroflavus* Lloyd, l.c.

Ventral surface a pronounced sulphur yellow.

Living *Nothofagus fusca* trunk.

Day's Bay, Wellington; Nov. 1926; *D. W. McKenzie!*

Distribution: Tropical Asia and America, Australia, New Zealand.

*F. australis* is in literature regularly confused with the preceding species, so that numerous records of its occurrence in different localities are probably doubtful. Lloyd, also, regularly confused it with *F. applanatus*, for he states (26, p. 265): "It is a time-honoured custom to refer every *Fomes* of the section *Ganodermus* that came from the tropics to *F. australis*. . . . In the sense of Fries (type at Kew) *F. australis* was based on a form of *F. applanatus* with thin context, hence the 'praelong' pores, but on comparison with the type form in Europe, we find it is in other respects exactly the same. . . . It is a mistake to consider that Fries had any definite species, distinct from *F. applanatus* which he named *F. australis*, or that any one else has had in connection with this name. *F. australis* is a convenient name to which to refer the tropical forms of *F. applanatus*, but we would restrict it to those that have thin context and long pores."

As has been shown (under *F. applanatus*) the species is quite distinct from *F. applanatus*, being separated chiefly by the much larger diameter of the tubes; the character present also in Fries' type at Kew, but overlooked by Lloyd and most other workers.

The form mis-named *Fomes nigrolaccatus* Cke., by Lloyd (l.c., p. 265) is not uncommon in New Zealand; and cannot be separated on any character from *F. australis*. The name *F. nigrolaccatus* cannot be used in any case, as according to Bresadola it is a synonym of *Polyporus galegensis* Mont.; which Lloyd, under the name of *Fomes galegensis*, considers cannot be maintained as distinct, even as a form, from *F. applanatus*.

*F. australis* is the cause of a serious heart rot of numerous timber trees in New Zealand (beech, matai, rimu). It is perhaps the largest fungus found in the Dominion, for one specimen the writer has examined was 90 cm. in width.

Lloyd's *F. annularis* and *F. Petchii* are forms only of this species, agreeing closely (judging from Lloyd's photographs and descriptions) with several New Zealand specimens, which the writer considers cannot be separated from *F. australis*. That names for every slight variant are superfluous becomes evident to any one dealing with abundant specimens, for then the range and extent of the variations of the species becomes clearly defined, and plants which if collected individually might by certain workers be considered as species, are seen to be forms only, linked up by numerous others with the species under consideration. It is because the majority of species in this

family have been based on single specimens, that there is so much confusion and so many synonyms in the literature dealing with the group.

Lloyd's *F. oroflavus* differs only in the sulphur yellow colour of the ventral surface of the pileus. The writer has seen only one specimen with this character, so does not know whether it is constant, or merely accidental; but as other collections have been recorded with the same feature, it seems worthy of a varietal name.

6. *Fomes subornatus* (Murrill) Lloyd, *Syn. Gen. Fomes*, p. 269, 1915. (Figs. 14-16, 17, c.)

*Ganoderma subornatum* Murr., *Bull. Torr. Bot. Cl.*, vol. 34, p. 477, 1907.

*F. pseudoaustralis*, Lloyd, *l.c.*

*F. polyzonus*, Lloyd, *l.c.*

*F. Koningsbergii* Lloyd, *l.c.*, p. 270.

Pileus applanate, seldom unguulate, not infrequently sub-resupinate, often irregular in shape, and with a lateral stipe-like projection which often attains considerable length, 2-15 x 5-18 x 2-5 cm.; surface with a hard crust, firm, black or brown, sometimes polished, sulcately zoned, often tuberculate and irregular; context chocolate brown or umber, often zoned concentrically with bands of the same nature as the crust, tough, firm, occupying about one half the pileus, margin irregularly crenate, lobed or even, rounded; tubes cinnamon, stuffed, obscurely strатose, ventral surface ranging in colour from cream to umber, even or more often rugulose or irregularly pitted; mouths minute, about 0.1 mm. diam., walls thick, 0.2-0.25 mm. thick; spores 6-7.5 x 6-6.5 mmm., shortly elliptical, truncate or not, pallid chestnut, minutely but distinctly verruculose.

Habitat: On fallen trunks of *Podocarpus spicatus* and *Dacrydium cupressinum*.

Weraroa, Wellington; Sept. 1919; *G.H.C.*

Whakarewarewa, Rotorua; Dec. 1923; *State Conservator!*

Wilton's Bush, Wellington; Nov. 1926; *D. W. McKenzie!*

Distribution: Phillipines, Madagascar, Java, New Zealand.

The species is most closely related to *F. applanatus*, but differs in the more irregular shape, the usual lateral stipe-like projection, and especially in the usually pitted and rugulose ventral surface, and the thick walls of the tubes.

It will be seen that Lloyd's *F. pseudoaustralis*, *F. polyzonus* and *F. Koningsbergii* are merely variants of the species under consideration, and cannot be separated on any character, for all characters he considers as specific, as shining laccate crust, zones of crust in context, etc., may be present or absent in different plants of the same collection.

#### DOUBTFUL AND EXCLUDED SPECIES.

The following species have been recorded as occurring in New Zealand by different workers, chiefly Lloyd. The writer has not seen specimens.

(a) *Fomes Clelandii* Lloyd. In *Letter 68*, p. 8, 1918, Lloyd records this species as being collected in New Zealand by W. A. Scarfe.

(b) *Fomes fraxineus* (Bull.) Fr. In *Letter 49*, p. 9, 1914, Lloyd doubtfully records this species as being collected in New Zealand by W. A. Scarfe.

(c) *Fomes Hauslerianus* (Henn.) Lloyd.

This species, described from specimens collected on tree trunks at Ohaupo, Auckland, by Hauesler, it is not possible to place owing to the faulty description. Lloyd (*Syn. Stip. Polyp.*, 109, 1912) states that he did not find the type at Berlin. On these counts the species should be removed from the literature.

(d) *Fomes hornodermus* Mont. recorded by Lloyd (from New Zealand) is probably a misdetermination of *F. hemitephrus* (q.v.). This is made more certain by a note in *Letter 67*, p. 13, 1918, where Lloyd states that he does not know any method of separating *F. hemitephrus* from *F. hornodermus*.

(e) *Fomes martius* Lloyd. This as Lloyd has shown, *Letter 65*, p. 7, 1917, is a synonym of *F. hemitephrus*.

(f) *Fomes nigrolaccatus* Cke. In *Letter 63*, p. 7, 1916, Lloyd records this species as being collected in New Zealand. As has been shown, under *F. australis*, the plants he has determined as this species belong to *F. australis*; and furthermore, that *F. nigrolaccatus* cannot be used as a valid name, as it is a synonym of another species.

(g) *Fomes pinicola* has doubtfully been recorded by Lloyd as occurring in New Zealand. As shown the writer believes he has mis-determined a specimen of *F. hemitephrus*.

(h) *Fomes pomaceus* (Pers.) Big. et Guill. Lloyd, *Myc. Notes*, p. 1125, 1922, records this as being collected in New Zealand by J. Mitchell.

(i) *Fomes Robinsoniae* (Murr.). Lloyd records this in *Letter 63*, p. 15, 1916, as being collected in New Zealand, but as shown, it is a synonym of *F. robustus*.

(j) *Fomes rufoflavus* (Berk. et Curt.) Sacc. Lloyd has determined for the writer one collection as above. The specimens have only one tube layer, and will therefore be considered under the genus *Polyporus* (as *P. Braunii* Rabenh.). It is, like *Polyporus gilvus*, one of those plants which have usually one layer of tubes, but which under certain conditions, develop several strata. As other characters tend to link it with *Polyporus*, it will be treated as such, as is usually done in the case of *P. gilvus*, though several workers consider it a valid *Fomes*. The peculiar cystidia present are also unlike any encountered in the species of *Fomes* examined by the writer, and recall those present in *Poria eupora*.

(k) *Fomes senex* (Nees et Mont.) Fr. Lloyd has recorded two collections of this plant from New Zealand (*Letter 60*, p. 2, 1915 and *Letter 65* p. 11, 1917). The writer believes he has misdetermined plants of *F. zelandicus*, which, as has been shown, agree in all particulars save the hyaline spores, with *F. senex*.

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17. — *Genera Hymenomycetum*, 17 pp. 1836.
18. — *Epicrisis systematis mycologici*, 608 pp. 1838.
19. — *Novae Symbolae Mycologicae*, 119 pp., 1851.
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## 2.—The Genus *Polyporus* (including *Polystictus*).

Most of the species of the Polyporaceae are grouped under this genus, upwards of 1,500 having been described to date. As an outline of the classification of this and related genera has been given in the previous part, further reference will be unnecessary. The genus was first established by Micheli (1729), but was not generally recognized until the appearance of Fries' *Systema* (6), Linnaeus, and later Persoon, using the generic name *Boletus* for polyporoid species.

As has been shown, it was separated from *Fomes* in that the tubes form a single stratum, and not a series,\* and is separated from *Trametes* in that the proximal ends of the tubes form an even layer through all being sunk to the same depth into the context. In *Trametes*, they occur at different depths, often giving a very irregular appearance to their proximal surface.

### 2. *Polyporus* Micheli ex Fries, *Syst. Myc.*, vol. 1, p. 341, 1821.

*Grifolia* Gray, *Nat. Arr. Brit. Pl.*, vol. 1, p. 643, 1821.

*Coltricia* Gray, *l.c.*, p. 644.

*Strilia* Gray, *l.c.*, p. 645.

*Albatrellus* Gray, *l.c.*

*Sistotrema* Pers. ex Fr., *Syst. Myc.*, vol. 1, p. 426, 1821.

*Ceriumyces* Cda., in Sturm *Deut. Fl.*, p. 133, 1837.

*Ptychogaster* Cda., *l.c. Fung.*, vol. 2, p. 24, 1838.

*Gloeoporus* Mont., *Ann. Sci. Nat.*, ser. 2, vol. 17, p. 120, 1842.

*Enslinia* Fr., *Summa Veg. Scand.*, p. 399, 1849.

*Polystictus*, Fr., *Nov. Symb.*, p. 70, 1851.

*Merisma* Gill., *Champ. Fr.*, vol. 1, p. 688, 1878.

*Polyporellus* Karst., *Medd. Soc. Faun. et. Fl. Fenn.*, vol. 5, p. 37, 1879.

*Bjerkandera* Karst., *l.c.*, p. 38.

*Hansenia* Karst., *l.c.*, p. 39.

*Inonotus* Karst., *l.c.*

*Inoderma* Karst., *l.c.*

*Bresadolia* Speg., *Anal. Soc. Cientf. Arg.*, vol. 10, p. 15, 1880.

*Piptoporus* Karst., *Rev. Myc.*, vol. 3, p. 17, 1881.

*Polypilus* Karst., *l.c.*

*Postia* Karst., *l.c.*

*Tyromyces* Karst., *l.c.*

*Hapalopilus* Karst., *l.c.*, p. 18.

*Meripilus* Karst., *Bidr. Finl. Nat. och Folk.*, vol. 37, p. 33, 1882.

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\*Sometimes exceptions occur, especially in tropic and sub-tropic regions; for example *P. gilvus*, *P. Braunii* and *P. hirsutus* occasionally show the tubes in strata, each stratum usually being separated from the other by an intervening layer of context.

- Myriadoporus* Peck, *Bull. Torr. Bot. Cl.*, vol. 11, p. 27, 1884.  
*Caloporus* Quel., *Ench. Fung.*, p. 164, 1886.  
*Leucoporus* Quel., *l.c.*, p. 165.  
*Pelloporus* Quel., *l.c.*, p. 166.  
*Cerioporus* Quel., *l.c.*, p. 167.  
*Cladomeris* Quel., *l.c.*  
*Inodermus* Quel., *l.c.*, p. 173.  
*Leptoporus* Quel., *l.c.*, p. 175.  
*Coriolus* Quel., *l.c.*  
*Melanopus* Pat., *Hym. Eur.*, p. 137, 1887.  
*Spongipellis* Pat., *l.c.*, p. 140.  
*Phaeoporus* Schroet., *Krypt. Fl. Schles.*, vol. 3, p. 489, 1888.  
*Oligoporus* Bref., *Unters.*, vol. 8, p. 114, 1889.  
*Mucronoporus* Ell. et Ev., pp., *Jour. Myc.*, vol. 5, p. 28, 1889.  
*Onnia* Karst., *Finl. Basidsv.*, p. 326, 1889.  
*Laccocephalum* McAlp. et Tepp., *Proc. Roy. Soc. Vic.*, vol. 7, p. 166, 1894.  
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*Phaeolus* Pat., *l.c.*, p. 86.  
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*Porodiscus* Murr., *l.c.*, p. 432.  
*Romellia* Murr., *Ibid.*, vol. 31, p. 338, 1904.  
*Coltriciella* Murr., *l.c.*, p. 348.  
*Abortiporus* Murr., *l.c.*, p. 421.  
*Cyclomycetella* Murr., *l.c.*, p. 422.  
*Poronidulus* Murr., *l.c.*, p. 425.  
*Laetiporus* Murr., *l.c.*, p. 607.  
*Trichaptum* Murr., *l.c.*, p. 608.  
*Pogonomyces* Murr., *l.c.*, p. 609.  
*Corioloopsis* Murr., pp., *Ibid.*, vol. 32, p. 358, 1905.  
*Flaviporus* Murr., *l.c.*, p. 360.  
*Nigroporus* Murr., *l.c.*, p. 361.  
*Dendrophagus* Murr., *l.c.*, p. 473.  
*Spongiporus* Murr., *l.c.*, p. 474.  
*Rigidoporus* Murr., *l.c.*, p. 478.  
*Earliella* Murr., *l.c.*  
*Cubamyces* Murr., *l.c.*, p. 480.  
*Microporellus* Murr., *l.c.*, p. 483.  
*Flaviporellus* Murr., *l.c.*, p. 485.  
*Aurantiporellus* Murr., *l.c.*, p. 486.  
*Aurantiporus* Murr., *l.c.*, p. 487.  
*Pycnoporellus* Murr., *l.c.*, p. 489.  
*Phaeolopsis* Murr., *l.c.*  
*Tomophagus* Murr., *Torreya*, vol. 5, p. 197, 1905.  
*Cycloporellus* Murr., *Bull. Torr. Bot. Cl.*, vol. 34, p. 468, 1907.  
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*Porodisculus* Murr., l.c., p. 47.  
*Tyromyces* Murr., *Mycologia*, vol. 4, p. 96, 1912.  
*Amurodermus* Lloyd, *Syn. Stip. Polyp.*, p. 110, 1912.  
*Lignosus* Lloyd, l.c., p. 122.  
*Petaloides* Lloyd, l.c., p. 129.  
*Merismus* Lloyd, l.c., p. 148.  
*Spongiosus* Lloyd, l.c., p. 157.  
*Pelloporus* Lloyd, l.c., p. 162.  
*Ovinus* Lloyd, l.c., p. 166.  
*Lentus* Lloyd, l.c., p. 170.  
*Ungularia* Laz., pp., *Polip. Esp.*, p. 113, 1917.  
*Polystictoides* Laz., l.c., p. 145.

Pileus stipitate, sessile (when usually dimidiate) or resupinate; stem central, lateral or absent, simple or branched; context white or coloured, fleshy, corky, coriaceous or sub-woody, but not gelatinous; tubes merging with the context, or distinct and separable, round or irregular, at proximal ends sunk the same depth into the context; cystidia (or setae) present or absent, hyaline or coloured; spores continuous, hyaline or coloured, smooth or echinulate; basidia unicellular, sterigmate, usually tetrasporous.

Habitat: Ligneous or terrestrial.

Distribution: World-wide.

As is shown by the synonymy, the genus has proved a difficult one for the systematist, for not only is there considerable differences of opinion as to specific characters, but also as to generic characters. As has been shown in the previous part, the majority of these genera are based on inconstant characters, and cannot be maintained; many others are monotypic and often based on freaks. One or two require further discussion before being dismissed. *Polystictus*, as has been shown, cannot be maintained as a genus, as it is not possible to separate it from many species of *Polyporus*. *Ceromyces* and *Ptychogaster* are based on abnormal forms which have not developed a tube layer. *Gloeoporus* is based on the presence of a distinct separable hymenial layer; quite a good generic character, but to avoid complication its use is considered unnecessary in a flora where there are so few species. Lloyd (10) has been careful to point out that he has considered the names he uses as being sectional only, yet under his illustrations and in his indices, he uses these sectional names in a generic sense; hence they must be listed as synonyms of *Polyporus*. The remainder may be dismissed without further mention. Their only function is to illustrate what confusion can be caused in literature by the erection of genera on the slightest pretext.

## Table of distribution of the New Zealand species.

Species.	Distribution:
<i>Polyporus</i>	
<i>adustus</i>	N.Z., Aus., Europe, N. America, Asia.
<i>anthracophilus</i>	N.Z., Aus.
<i>arcularius</i>	N.Z., Aus., Europe, N. America.
<i>Berkeleyi</i>	N.Z., Aus., — N. America, — Japan.
• <i>Braunii</i>	N.Z., — Europe, Tropical East and W. Indies.
<i>catervatus</i>	N.Z.
<i>Colensoi</i>	N.Z.
<i>dichrous</i>	N.Z., Aus., Europe, N. & S. Am., Asia, S. Africa.
<i>Eucalyptorum</i>	N.Z., Aus.
<i>gilvus</i>	N.Z., Aus., N. and S. America, Europe, Tropics generally.
<i>hirsutus</i>	N.Z., Aus., Europe, America, Asia.
<i>melanopus</i>	N.Z., Aus., Europe.
<i>oblectans</i>	N.Z., Aus., Europe, N. America, Tropical Asia.
<i>proprius</i>	N.Z.
<i>radiatus</i>	N.Z., Aus., Europe, N. America.
<i>tabacinus</i>	N.Z., Aus., S. America, Africa, East Indies.
<i>versicolor</i>	N.Z., Aus., N. America, Europe, Asia.

Thus three species of those described in this paper are endemic, two others extend to Australia; and the remainder have a wide distribution. Most occur on wood, but one—*P. Colensoi*—grows on the ground. Of those with a ligneous habitat, but two are of economic importance in that they attack living trees.

*P. Eucalyptorum* is the cause of a serious heart-rot of *Nothofagus* spp. in our forests; and *P. versicolor* has proved a troublesome wound-parasite of peach trees in the Auckland province.

## KEY TO THE SPECIES.

Pileus stipitate.	
Stipe and/or pileus compound.	
Spores strongly echinulate	1. <i>P. Berkeleyi</i>
Spores smooth.	
Pileoli soft and fleshy; plants terrestrial.....	2. <i>P. Colensoi</i>
Pileoli hard and woody; plants ligneous.....	3. <i>P. anthracophilus</i>
Stipe and pileus simple.	
Stipe central (seldom excentric).	
Exterior of pileus strongly hispid	4. <i>P. oblectans</i>
Exterior of pileus smooth or almost so.	
Tube layer normal, tubes large	5. <i>P. arcularius</i>
Tube layer apparently inverted; tubes minute	6. <i>P. catervatus</i>
Stipe excentric or lateral, prominent, black	7. <i>P. melanopus</i>
Pileus sessile; dimidiate or effused-reflexed, often imbricate.	
Context white or isabelline.	
Spores smooth.	
Context homogenous with tubes.	
Cystidia absent.	
Pileus strongly hirsute	8. <i>P. hirsutus</i>
Pileus tomentose or smooth.	
Pileus strongly zoned	9. <i>P. versicolor</i>
Pileus not or scarcely zoned	10. <i>P. adustus</i>
Cystidia present, hyaline	11. <i>P. Braunii</i>

Context distinct from tube layer.	
Context fleshy, tube layer subgelatinous.....	12. <i>P. dichrous</i>
Context and tubes fleshy-corky .....	13. <i>P. Eucalyptorum</i>
Spores strongly echinulate .....	14. <i>P. proprius</i>
Context ferruginous or umber.	
Pileus silky on the surface .....	16. <i>P. tabacinus</i>
Pileus smooth or strigose-tuberculate.	
Spores hyaline .....	15. <i>P. gilvus</i>
Spores coloured .....	17. <i>P. radiatus</i>

1. **Polyporus Berkeleyi** Fries, *Nov. Symb.*, p. 40, 1851.

*P. subgiganteus* Berk. et Curt., *Grev.*, vol. 1, p. 49, 1872.

*P. Dickensii* Berk., *Jour. Linn. Soc.*, vol. 16, p. 50, 1878.

*P. Beatiei* Peck, *Rept. N.Y. State Mus. Nat. Hist.*, vol. 30, p. 36, 1878.

*Polyporus lactifluus* Peck, *Bull. Torr. Bot. Cl.*, vol. 8, p. 51, 1881.

*P. anax* Berk., *Grev.*, vol. 12, p. 37, 1883.

*P. zelandicus* Cke., *Grev.*, vol. 16, p. 113, 1888.

*Grifola Berkeleyi* (Fr.) Murr., *Bull. Torr. Bot. Cl.*, vol. 31, p. 337, 1904.

Pileus stipitate, compound, pileoli arising from a common base, irregular in size and shape, centrally or laterally stipitate, clavate, spathulate, fan-shaped, 6-20 x 1-15 x 0.3-3 cm., margins lobed, or deeply cleft into numerous sub-pileoli; surface fawn, fulvus or bay brown, finely tomentose or farinaceous, often rugulose and obscurely striate; context white to isabelline, firm, soft-punky, up to 2 cm. thick, sometimes staining orange when bruised; tubes cream to isabelline, sometimes staining orange when bruised, when old often bay brown or ferruginous, 1-2 mm. long, irregular in shape, polygonal, or more usually laterally compressed, 0.5-2 mm. diam., decurrent, dissepiments thin, often lacerate; cystidia absent; spores globose, hyaline, 6-8 mmm. diam. (including spines), strongly echinulate, abundant.

Habitat: At bases of trees growing in rich humus.

Base of *Nothofagus* sp. stump.

Arthur's Pass, Canterbury; 500m.; Feb., 1927; *J. B. Cleland!*

Base of *Dacrydium* sp. stump.

Mt. Egmont, Taranaki; 1000m.; Feb., 1927; *J. B. Cleland!*

Distribution: North America, Japan, Australia, New Zealand.

Separated from all other species present in New Zealand, save *P. proprius*, by the presence of the large, strongly echinulate, hyaline spores. The compound nature of the pileus also is characteristic.

The plant is exceedingly variable in its size and shape, as may be seen by the remarks of other workers, quoted below; consequently such characters as size, surface markings of the pileoli, and shape of the plant, cannot be considered specifically. Murrill (15), in discussing this plant, states "I have seen plants two feet in width and over a foot high, with several lobes six to nine inches in diameter.

They usually grow under oak trees, often between the enlarged bases of the main roots, and are in close connection with some supply of humus, either from buried wood or very rich leaf-mould." Lloyd (9, p. 36) gives the following particulars regarding the species: "We have a specimen in our museum. . . of the following dimensions when fresh: length, 3 feet; width, 2 feet 2½ inches; height, 1 foot 1 inch; weight, 43 lbs."

The New Zealand specimens at hand differ in that the pileoli are smaller and more lobed; but in all other particulars, nature and colour of the context, shape, colour and size of the tubes, and especially the spores, our plants agree very closely with authentic North American specimens of *P. Berkeleyi* in the writer's herbarium. To maintain the plant as specifically distinct on the smaller size and more lobed nature of the pileoli in such a variable species as this seems to be unnecessary, and would only tend to confusion. The species was previously described from New Zealand as *P. zelandicus*; according to Bresadola and Lloyd the type of this at Kew is identical with *P. Dickensii* from Japan. This in turn Lloyd considers to be a synonym of *P. Berkeleyi*, a belief the writer considers is substantiated by the fact that the specimens listed above do not materially differ, save in the points enumerated, from *P. Berkeleyi*.

## 2. *Polyporus Colensoi* Berkeley, *Fl. N.Z.*, vol. 2, p. 178, 1855.

(Fig. 1.)

Pileus stipitate, compound, numerous pileoli arising from a common central or lateral, dichotomously branched stipe, whole plant compact, up to 20 cm. broad; pileoli small, 1-3 cm. broad, fan-shaped or cuneiform; exterior roughened, papillate-striate, dingy-grey to umber, margin entire, very thin; context thin, 1-2 mm., corky when dry, fleshy when fresh, isabelline; tubes decurrent, uneven, irregular in shape, hexagonal or elongate, sometimes sinuate, 1-3 mm. long, laterally compressed, dissepiments thin, often toothed; cystidia absent; spores globose to subglobose, 4-5.5 mmm. diam., hyaline, smooth, abundant.

Habitat: On clay soil at the base of trees in the forest.

York Bay, Wellington; Nov., 1921; *E. H. Atkinson!*

Distribution: ? Australia, New Zealand.

Characterized by the compound pileus, small fan-shaped pileoli, irregular toothed tubes, and subglobose, hyaline, smooth spores. It is separated from the preceding by the smaller pileoli and smooth spores; and from *P. anthracophilus* by the thin fleshy-corky nature of the context, much smaller pileoli and much larger diameter of the tubes.

## 3. *Polyporus anthracophilus* Cooke, *Grevillea*, vol. 12, p. 16, 1883.

(Fig. 2.)

*Fomes anthracophilus* Cke., *l.c.*

*Polyporus rosettus* Lloyd, *Myc. Notes*, p. 601, 1916.

Pileus laterally stipitate, compound; pileoli variable in size and shape, fan-shaped, lobed and sub-lobed, margin toothed, up to 6 x 6 cm.; exterior minutely velutinate or farinose, sometimes tuberculose,

bay brown, umber or chocolate brown, radially obscurely sulcate and striate; context hard and woody, but thin, 0.5-2 mm., white or isabelline, sometimes with green or brown colour zones, brown beneath the cuticle; tubes uneven below, decurrent, isabelline, 1-4 mm. long, 4-6 to mm., irregularly labyrinthiform, angular or round, dissepiments thin, often toothed, whole layer firm and tough; cystidia absent; spores subglobose to pip-shaped, 4-6 x 3-4 mmm., hyaline, smooth, abundant.

Habitat: Dead driftwood on river banks; bases of stumps of trees in the forest.

Palmerston North, Wellington; July, 1919; *G. H. C.*

Otaki Forks, Wellington; July, 1922; *E. H. Atkinson!*

Ashburton, Canterbury; Aug., 1925; *J. C. Neill!*

Distribution: Australia; New Zealand.

Characterized by the compound nature of the plant, the freely lobed, hard and woody pileoli, and smooth, hyaline spores. Lloyd has named part of the Otaki collection as *P. rosettus*, which according to Bresadola (3, p. 30) is a synonym of *P. anthracophilus*.

4. *Polyporus oblectans* Berkeley, *Linn. Jour. Bot.*, vol. 4, p. 51, 1845.  
(Fig. 3.)

*P. parvulus* Klotzsch, *Linnaea*, vol. 8, p. 483, 1833.

*P. bulbipes* Fr., *Nov. Symb.*, p. 72, 1851.

*P. splendens* Peck, *Ann. Rept. N.Y. St. Mus.*, vol. 26, p. 68, 1874.

*Polystictus cinnamomeus* Sacc., *Mich.*, vol. 1, p. 362, 1878.

*P. salpincta* Cke., *Grev.*, vol. 8, p. 142, 1880.

*Polyporus subsericeus* Peck, *Ann. Rept. N.Y. St. Mus.*, vol. 33, p. 37, 1880.

*P. perdurans* Kalch. et Cke., *Grev.*, vol. 9, p. 1, 1880.

*Polystictus oblectans* (Berk.) Cke., *Hdbk. Aus. Fungi*, p. 138, 1892.

*Coltricia cinnamomea* (Jacq.) Murr., *Bull. Torr. Bot. Cl.*, vol. 31, p. 343, 1904.

Pileus stipitate, simple, orbicular, 2-3 cm. diam., plano-depressed, becoming umbilicate; surface bright cinnamon, seldom darker, shining, strigose-striate, at first zoned, becoming tawny and zoneless, margin fimbriate, sometimes lobed; context firm, tawny to umber, 0.5-2 mm. thick, coriaceous; stipe central, sometimes excentric, 2-3 cm. x 3-5 mm., bulbous at base or equal, silky or pruinose, solid; tubes decurrent, even, cinnamon or pallid umber, 1-2 mm. long, 2-3 to the mm., irregular in shape, margin often broadly sterile; cystidia absent; spores elliptical, 6-7 x 4-5 mmm., smooth, pallid yellow, abundant.

Habitat: On rotting buried sticks on the ground.

Sandhills, Weraroa, Wellington; Oct. 1919, 1920, 1922;  
*E. H. Atkinson!*

Distribution: Britain, Europe, North America, Tropical Asia, Australia, New Zealand.

Characterized by the bright cinnamon colour, usually central stipe (excentric in several specimens at hand), small tawny tubes, and pale yellow, smooth, elliptical spores. It resembles in general appearance the following species, but is readily separated by the

cinnamon, shining, strigose-striate surface of the pileus and much smaller tubes.

Considerable confusion exists in literature as to the specific name to be applied to this species. Lloyd (7, p. 7), in comparing *P. oblectans* with the American form (which he considered specifically distinct and labelled *P. cinnamomeus*) stated: "... In the American plant the fibrils of the pileus are appressed and the pileus smooth. In the Australian plant the fibrils in the centre of the pileus are erect and the pileus subsquamous. In addition the spores of the Australian plant are more round being about  $6 \times 7$  mm." As to the erect fibrils, this feature is present or absent in different plants in the collections listed above, so cannot be considered as being of specific value. Their presence would appear to depend on the age of the plants when collected as they are usually in evidence in young plants, but absent in older and fully matured specimens. The spores in the New Zealand plants are  $6.7 \times 4.5$  mm.; and according to Murrill (16, p. 92) those of the American plants are  $6.8 \times 4.6$  mm. Rea (17, p. 575), records them from England as being  $6.7 \times 4.5$  mm., so that Lloyd's record for the American plant "varying from  $5 \times 6$  to  $6 \times 10$  mm." is apparently based on faulty measurement. It will thus be seen that the spores of the New Zealand and Australian forms (for Cleland and Cheel (4, p. 492) record them from Australia as being  $7.7.3 \times 5.2$  mm.) are the same as the European and North American forms; therefore as both distinctions as drawn by Lloyd disappear, it is evident the Australasian plant is the same as the one occurring elsewhere.

The specific name *cinnamomeus*, commonly applied to this plant, cannot be used for it antedates the starting point of modern nomenclature in the Polyporaceae (6), and was not used specifically by Fries himself. The second name *parvulus* applied to the species by Klotzsch cannot be used, as it was applied to a different plant the previous year by Schweinitz; therefore *oblectans*, being next in order, is the specific name to be applied to this species.

5. *Polyporus arcularius* (Batsch) Fries, *Syst. Myc.*, vol. 1, p. 342, 1821. (Fig. 4.)

*P. alveolaris* Bosc ex Fr. *Epi.*, p. 431, 1838.

*P. agariceus* Berk., *Ann. Mag. Nat. Hist.*, vol. 10, p. 371, 1842.

*Favolus Curtisii* Berk., *Grev.*, vol. 1, p. 68, 1872.

*F. squamiger* Berk., *Jour. Linn. Soc.*, vol. 13, p. 166, 1872.

*Polyporus collybioides* Kalch., *Grev.*, vol. 10, p. 94, 1881.

*Leucoporus arcularius* (Batsch) Quel., *Fl. Fr.*, vol. 1, p. 402, 1888.

*Polyporus Penningtonii* Speg., *Myc. Argent.*, ser. 2, p. 52, 1902.

*P. arculariellus* Murr., *Bull. Torr. Bot. Cl.*, vol. 31, p. 36, 1904.

*P. arculariformis* Murr., *Torreya*, vol. 4, p. 151, 1904.

Pileus stipitate, simple, orbicular, 4-8 cm. diam., convex, then plane, usually umbilicate, at first fleshy, becoming coriaceous; exterior at first squamulose, becoming smooth and fuscous, margin finely tomentose, fimbriate or smooth, even, variegated; context thin, 0.1-1 mm., white, drying isabelline, firm and membranous; stipe 5 cm.  $\times$  3-6 mm.,

concolorous, squamulose, hollow or stuffed; tubes even, decurrent, concolorous, elongate or compressed polygonal, 2.3 x 0.5-1.5 mm., dissepiments thin, entire; cystidia absent; spores elliptical, often slightly allantoid, 6-8 x 2-3.5 mmm., hyaline, smooth, abundant.

Habitat: On dead wood lying on the surface of pastures near margins of the forest.

Weraroa, Wellington; Oct. 1919; *E. H. Atkinson—G.H.C.*  
(two abundant collections).

Distribution: England, Europe, North America, Australia, New Zealand.

One of the finest plants of the genus, characterized by the simple stipe, orbicular, usually umbilicate, dark-coloured pileus, and compressed-hexagonal, large decurrent tubes. It varies considerably, particularly in the colour and degree of roughness of the pileus, and size and shape of the tubes.

What appears to be an extreme form, known as *P. brumalis*, is often confused with this species. Apparently separation is possible only on the larger, more irregular tubes of *P. arcularius*, but intermediate forms are common elsewhere making separation in such cases a difficult matter. (See, for example, Lloyd's remarks re "The named and misnamed species of the Exsiccatae," *Letter 52*, p. 6).

The spores in both species are the same size, yet Rea (17, p. 576) gives those of *P. arcularius* as being globose and 3 mmm. diameter!

The plant is abundant in New Zealand, and also in Australia, according to Cleland and Cheel (4, p. 497); *P. brumalis*, on the other hand, has not been collected in Australasia (save for one reference by Cooke in the *Handbook*, p. 112, most probably misdetermined).

## 6. *Polyporus catervatus* Berkeley, *Fl. N.Z.*, vol. 2, p. 180, 1855. (Fig. 5.)

*Polystictus catervatus* (Berk.) Sacc. *Syll. Fung.*, vol. 6, p. 289, 1888.

Pileus apparently inverted, saucer-shaped or disciform, 0.1-1 cm. diam., caespitose, when forming masses up to 5 cm. across, attached by a central, basal, stipe-like projection; exterior finely tomentose, radially striate, pallid isabelline, fuscus when old; context thin, 0.5 mm. or less, isabelline, fleshy; tubes apparently superior, actually ventral, ochraceous or dingy-brown, even, margin broadly sterile, 1-3 mm. long, 10 or more to the mm., irregular in shape, often laterally crushed; cystidia absent; spores globose, 4-5 mmm., hyaline, smooth, abundant.

Habitat: On the under side of fallen logs in the forest.

Weraroa, Wellington; Sept. 1919; *G.H.C.*

May 1923; *J. C. Neill—G.H.C.*

Distribution: Endemic.

One of the most unique species of the genus, which could be made the type of a "new genus." In herbarium specimens the plant appears like the stalked apothecium of a *Sclerotinia*, the saucer-shaped portion being occupied by the tube-layer. It grows on the

under side of logs, so that the hymenium is really ventral, but unless specimens were seen growing *in situ*, it would appear to be superior. The plant often appears to be of irregular size, through several pilei becoming united at their margins, but their individual structure is always apparent, owing to the junction between pilei being quite visible, and to the fact that each possesses its small stipe. The tubes are so minute as to be seen clearly only with a lens; so possibly the species may have been described also as a *Stereum*.

From the description given by Berkeley, it would be impossible to place the plant, nor would reference to the type aid diagnosis, as according to Bresadola (2, p. 240): "*Specimen Colensoi valde dubium, imperfectum, indeterminabile; specimen Traversii est = P. con-crescens Mont.*" Fortunately Berkeley illustrated the species (*l.c.*, pl. CV., f. 1), and as will be seen by our photograph our plant agrees exactly with Berkeley's illustration; hence despite the absence of a recognisable type the name can be applied to the collections at hand with confidence.

Only one other plant has a similar pendulous habit, namely *P. dependens*, but this differs in the coloured spores, large diameter of the tubes, and different colour and shape of the pileus. *P. catervatus* is not related to any of the plants described in this paper, but is placed in its present position solely on account of the presence of a central, simple stipe, if this structure can be termed such.

7. **Polyporus melanopus** (Schwarz) Fries, *Syst. Myc.*, vol. 1, p. 347, 1821. (Figs. 6, 7.)

*P. flavescens* Rostk., in Sturm *Deut. Fl.*, vol. 4, t. 15, 1838.

*P. leprodes* Rostk., *l.c.*

*P. infernalis* Berk., Hook. *Jour. Bot.*, vol. 2, p. 637, 1843.

*P. versiformis* Berk., *Ibid.*, vol. 4, p. 137, 1852.

*P. Pancheri* Pat., *Bull. Soc. Myc. Fr.*, vol. 3, p. 168, 1887.

*Melanopus melanopus* (Schwarz) Bourd. et Galz., *Bull. Soc. Myc. Fr.*, vol. 41, p. 112, 1925.

Pileus stipitate, infundibuliform, or less commonly spathulate, up to 10 c.m. across, upturned when young, frequently incurved when old, margin entire or coarsely lobed; exterior at first minutely squamulose, becoming glabrous, often with scattered, minute, raised radial striae, pallid yellow to umber (colour depending on age of specimens); stipe central or excentric, solid, bay brown to black, covered with a thickened cuticle (which is often absent), 2.5 cm. x 1.8 mm., curved, unequal, usually thickened downwards, often minutely velvety; context tough, coriaceous, 1.2 mm. thick, isabelline; tubes decurrent, white, becoming isabelline, even, margins sterile, orifices often velutinate, angular, 6.8 to mm.; cystidia absent; spores elliptical, 6.8 x 2.3.5 mm., hyaline, smooth, abundant.

Habitat: On rotting branches lying on the forest floor.

Weraroa, Wellington; Jan. 1920; *G.H.C.*; June 1923, *J. C. Neill—G.H.C.*

Distribution: Britain, Europe, Australia, New Zealand.

Characterized by the frequent infundibuliform shape of the pileus, the prominent, black stipe, often with a distinct cuticle covering the base, and thin, coriaceous context.

The plant is one of a small series of closely related forms or species. Considerable confusion exists in literature as to the limits of these, and it appears to the writer, that two recognizable species only occur, the many others being but variants of these. That this confusion is evident will be made clear by the following example. Part of one collection was sent abroad to one authority, who named it *P. infernalis*; part of the same collection, sent to a second authority was named *P. dictyopus*; yet a third sending of the same collection was named by a third authority *P. melanopus*. If material and "authorities" had held out, doubtless a considerable number of names would have been accumulated! Thus three "species" are present, in one collection, taken at the same time from the same log. Reference to available literature has not tended to clarify the position; for example, Lloyd (10, p. 180) states that *P. infernalis* is a synonym of *P. dictyopus*, which in turn he considers a form of *P. varius-picipes*; and *P. picipes* he considers a form of *P. varius*. By Bourdot and Galzin (1, p. 110) *P. picipes* is considered a synonym of *P. varius*. *P. elegans*, a form considered a form of *P. varius* by Lloyd, is considered a valid species by Bourdot and Galzin, yet by Rea (17, p. 577) is considered a synonym of *P. varius*.

Comparison of our material with herbarium material from abroad shows that certain plants are identical in every particular with *P. melanopus*, so this name is used for the collections in question, a name which has previously been used by Masee (14, p. 5) for plants from New Zealand. *P. infernalis*, judging from descriptions, does not appear to differ in any particular, so is here considered as a synonym. *P. dictyopus* appears to be quite a different plant, and if not a valid species, is a form of *P. varius*. *P. Pancheri* is a form with radial striae on the pileus, a character which appears to be accidental, as it occurs on certain of the plants at hand. It is referred by Lloyd to *P. dictyopus*, and according to him, by Kew authorities to *P. infernalis*. But Bresadola (2, p. 226) refers it as a synonym of *P. versiformis* Berk., which according to Lloyd (10, p. 188) is based on "two little specimens, one of which seems to be *P. melanopus*, the other I think different."

As to the differences between *P. varius* and *P. melanopus*: in literature these are not clearly defined, but from herbarium specimens the writer believes the two differ in the thickness and nature of the context, the former possessing a woody consistency, the latter being more coriaceous, thinner and usually of a different shape. The presence or absence of the black stipe, or whether it is velutinate or glabrous, cannot be considered as of much value, for in the collections at hand, occur forms with and without these characters. Some, taken from the same log, have ochraceous stipes, others have black; some are velutinate, others glabrous; still others possess a distinct cuticle covering the stipe, and this may in turn be velutinate or glabrous, black or ochraceous.

*P. melanopus* is another plant not related to any others present in the Dominion, yet placed in its present position on account of the presence of a definite stipe.

8. **Polyporus hirsutus** Fries, *Syst. Myc.*, vol. 1, p. 367, 1821.  
(Fig. 8.)

*Polystictus hirtellus* Fr., *Nov. Symb.*, p. 83, 1851.

*P. hirsutus* Fr., *l.c.*, p. 86.

*Coriolus hirsutus* Quel., *Fl. Myc.*, p. 389, 1888.

*C. nigromarginatus* (Schw.) Murr., *Bull. Torr. Bot. Cl.*, vol. 32, p. 649, 1906.

*Polystictus hirsutellus* Lloyd, *Letter 67*, p. 2, 1918; *nomen nudum*.

Pileus sessile, dimidiate, imbricate, often resupinate, at first soft and flexible, becoming thin, tough and coriaceous; surface strongly hirsute, of green, grey or brown concentric zones; context thin, 1-2 mm., white, becoming isabelline, corky; tubes even, grey to cinnamon, usually round, sometimes daedaloid, occasionally stratose, 3-4 to mm., 1-2 mm. long, margin sterile, dessipiments thin, entire; cystidia absent; spores cylindrical, 6-9 x 2.5-3.5 mmm., hyaline, smooth, abundant.

Habitat: On dead wood, sticks, etc., in damp places, as rubbish tips.

Weraroa, Wellington; Aug., Sept., 1919; *G.H.C.*

Kelburn, Wellington; Nov., 1926; *G.H.C.*

Marton, Wellington; Feb., 1927; *G.H.C.*

Distribution: Britain; Europe; Asia; America; Australia; New Zealand.

Characterized by the coriaceous, dimidiate pileus, hirsute, zoned surface, usually pallid colour of the tube layer, and cylindrical, hyaline spores.

The plant may be collected throughout the year on rotting branches and the like in damp places, as rubbish heaps; on these it produces a rapid white rot, irrespective of the host. In the plants from Marton, the pilei show the tubes to be in definite strata, like a *Fomes*, with layers of context between each stratum. It is evident that with these specimens, fresh pilei have grown over the old. It is such plants that tend to break down the division between *Polyporus* and *Fomes*; this peculiarity is apparently not rare, as it has been commented on by Lloyd (13). In certain plants, there is a tendency also for the proximal ends of the tubes to penetrate different depths into the context, the chief character of *Trametes*. Thus extreme forms of the plant could be placed equally well in either *Trametes* or *Fomes*.

The species closely resembles the following in structure, from which it may be separated by the strongly hirsute surface of the pileus.

9. *Polyporus versicolor* (L.) Fries, *Syst. Myc.*, vol. 1, p. 368, 1821.  
(Figs. 9, 11.)

*P. decipiens* Schw., *Trans. Am. Phil. Soc.*, p. 157, 1834.

*P. poecilus* Berk., *Ann. Mag. Nat. Hist.*, vol. 10, p. 372, 1842.

*Polystictus versicolor* (L.) Fr., *Nov. Symb.*, p. 86, 1851.

*P. azureus* Fr., l.c., p. 93.

*P. apophysatus* (Rostk.) Fr., *Hymen. Eur.*, p. 580, 1874.

*Coriolus versicolor* (L.) Quel., *Ench. Fung.*, p. 175, 1886.

*Polystictus decipiens* (Schw.) Sacc., *Syll. Fung.*, vol. 6, p. 262, 1888.

*P. aequus* Lloyd, *Myc. Notes*, p. 933, 1920.

Pileus dimidiate, imbricate, thin, gibbous or fan-shaped, when attached by a narrowed base, 2-10 cm. across; exterior smooth or more often finely pubescent with yellow or brown satiny zones alternating with smooth, or of zones of various colours as brown, blue, green or yellow; context thin, 0.5-2 mm., white or isabelline, compact; tubes even, 1-2 mm. long, about 4 to the mm., white, becoming isabelline, dissepiments thin, often toothed; cystidia absent; spores elliptical or cylindrical, 5-8 x 2-3 mmm., hyaline, smooth, abundant.

Habitat: On dead branches and stumps of trees.

Dead *Pinus radiata* stump.

Masterton, Wellington; Nov., 1919; *G.H.C.*

Dead *Prunus persica* branches.

Henderson, Auckland; Nov., 1920; *F. Moore!*

Dead *Acacia* stumps.

Ashburton, Canterbury; Aug., 1925; *J. C. Neill!*

Christchurch, Canterbury; Oct., 1922; *W. K. Dallas!*

Riccarton, Canterbury; Dec., 1925; *D. W. McKenzie!*

Tauranga, Auckland; Jan., 1924; *G.H.C.!*

Dead *Nothofagus* sp. log.

Mt. Waiopahu, Wellington; Oct., 1919; *G.H.C.*

Upright of old whare (timber unknown).

Clinton Valley, Otago; Jan., 1920; *E. H. Atkinson!*

Host unknown.

Bealey Gorge, Canterbury; 1881; *T. Kirk!*

Distribution: World-wide.

A polymorphic species, exhibiting so many variations that it is impossible to list them. All New Zealand collections are considered to belong to *P. versicolor*, though they vary to such an extent that many extreme forms cannot be differentiated from the closely related *P. zonatus* Fr., a "species" which the writer considers is not specifically distinct, but in the absence of authentic specimens, *P. zonatus* is not listed as a synonym. Bourdot and Galzin (1, p. 141) consider that *P. zonatus* is rare and typical only on the "tremble" (*Populus tremula*), on which host specimens have not been collected in New Zealand.

The species is also closely related to *P. hirsutus*, but may be separated by the velutinate, usually markedly zoned pileus, and by the frequent lobed dissepiments, a feature which does not occur with *P. hirsutus*.

*P. velutinus* so closely resembles *P. versicolor* that it is also often difficult to separate them; consequently the record of this species occurring in New Zealand given by Massee (14) is considered to be based on a misdetermination of *P. versicolor*. Bourdot and Galzin (1, p. 139) consider *P. velutinus* a synonym of *P. pubescens* Fr.

*P. versicolor* has proved a serious disease of peach-trees in the Auckland Province, producing a condition not unlike that caused by *Stereum purpureum*.

10. **Polyporus adustus** (Willd.) Fries, *Syst. Myc.*, vol. 1, p. 363, 1821. (Fig. 10.)

*P. crispus* Fr., *Obs. Myc.*, vol. 1, p. 127, 1815.

*P. pallescens* Fr., *Syst. Myc.*, vol. 1, p. 369, 1821.

*P. subcinereus* Berk., *Ann. Mag. Nat. Hist.*, vol. 3, p. 391, 1839.

*P. demissus* Berk., *Hook. Jour. Bot.*, vol. 4, p. 52, 1845.

*P. Halesiae* Berk. et Curt., *Ann. Mag. Nat. Hist.*, vol. 12, p. 434, 1853.

*P. Lindheimeri* Berk. et Curt., *Grev.*, vol. 1, p. 50, 1872.

*P. scanicus* Fr., *Hymen. Eur.*, p. 349, 1874.

*Polystictus adustus* Fr., *Hymen. Eur.* p. 549, 1874.

*Polyporus dissitus* Berk. et Br., *Jour. Linn. Soc.*, vol. 14, p. 48, 1875.

*P. gloeoporioides* Speg., *Mich.*, vol. 1, p. 231, 1878.

*Bjerkandera adusta* (Willd.) Karst., *Medd. Soc. F  n. Fl. Fenn.*, vol. 5, p. 38, 1879.

*Polyporus MacOwani* Kalch. et Cke., *Grev.*, vol. 10, p. 54, 1880.

*Myriadoporus adustus* Peck, *Bull. Torr. Bot. Cl.*, vol. 11, p. 27, 1884.

*Leptoporus adustus* (Willd.) Quel., *Fl. Myc.*, p. 388, 1888.

*Polystictus similans* (B. et C.) Sacc., *Syll. Fung.*, vol. 6, p. 117, 1888.

*Polyporus Burtii* Peck, *Bull. Torr. Bot. Cl.*, vol. 24, p. 146, 1897.

Pileus sessile, dimidiate, imbricate, often completely resupinate, 2-8 cm., often forming diffused areas up to 20 cm. long; exterior even, finely villose, frequently zoned, often rugulose; context white or greyish, corky, firm, 0.5-3 mm. thick; tubes even cinereous, 0.2-2 mm. long, often mere pits in the surface, margin broadly sterile, 4-5 to mm., dissepiments thin, firm, entire; spores elliptical, 4-6 x 2-3 mmm., hyaline, smooth, abundant.

Habitat: Dead wood, sticks and the like, on the forest floor.

Palmerston North, Wellington; May, 1919; *G.H.C.*

Weraoia, Wellington; Aug., 1919; *G.H.C.*

Distribution: Britain; Europe; India; North America; Australia; New Zealand.

The smoky-grey, short tubes and effused-reflexed pileus are the characters of the species. It varies considerably, hence the numerous synonyms. Most of the New Zealand plants are resupinate, but in the herbarium are European and North American plants typically dimidiate and imbricate.

The three preceding species, *P. hirsutus*, *P. versicolor* and *P. adustus* are structurally related, and form a natural group, characterized by the dimidiate habit, white or isabelline coriaceous context, and hyaline smooth spores.

11. **Polyporus Braunii** Rabenhorst, *Fung. Eur.* no. 2005, 1824.

*P. rufoflavus* Berk. et Curt., *Jour. Linn. Soc.*, vol. 10, p. 310, 1868.

*Fomes rufoflavus* (B. et C.) Sacc., *Syll. Fung.*, vol. 6, p. 191, 1888.

*Polystictus Braunii* (Rab.) Sacc., *l.c.*, p. 289.

*Polyporus Engelii* Harz., *Bot. Centr.*, vol. 1, p. 376, 1889.

*Polystictus Engelii* (Harz.) Sacc., *Syll. Fung.*, vol. 9, p. 188, 1891.

*Fomes Braunii* (Rab.) Bres., *Attl. Lett. Art. Ag. Rov.*, ser. 3, vol. 3, p. 74, 1897.

*Leptoporus Braunii* (Rab.) Pat., *Ess. Tax. Hymen.*, p. 85, 1900.

*Flaviporus rufoflavus* (B. et C.) Murr., *Bull. Torr. Bot. Cl.*, vol. 32, p. 360, 1905.

Pileus dimidiate, applanate, often resupinate, 0.5 x 1.3 x 0.2-0.5 cm.; surface rugulose, glabrous or finely tomentose, sometimes zoned; context fleshy, becoming horny, thin, 0.2-0.5 mm., pallid yellow; tubes even, irregular in shape, 8-11 to mm., pallid lemon yellow, sometimes stratosed, dissepiments very thin, entire; cystidia hyaline, encrusted-tuberculate, hollow, 32 x 8 mmm., inserted at an acute angle with apices downwards; spores obovate, 2.2.5 x 1.1.5 mmm., hyaline, smooth, abundant.

Habitat: On dead wood in the forest.

Weraoia, Wellington; July, 1919; *G.H.C.*

Distribution: Cuba; Venezuela; Ceylon; Borneo; Malacca; Europe; New Zealand.

A minute plant, characterized by the pallid-yellow colour of the context and tube layer, and especially by the large, hyaline, encrusted cystidia and minute hyaline spores. The New Zealand collections possess a single layer of tubes, but in certain European collections they occasionally occur in strata, and in consequence the species has by several authorities been referred to *Fomes*. This is one of those examples in which a plant normally of the *Polyporus* type, occasionally assumes a *Fomes* form; in such cases it appears that other characters must be considered before its generic position can be determined. As the plant has the fleshy context and structure of *Polyporus*, it is therefore referred to this genus, more especially as the tubes are not in strata in the collections at hand. The cystidia—characteristic of the species—are unlike any the writer has encountered in other species of the family, but resemble those present in European collections of *Poria eupora*.

The distribution of the plant, as given by Bourdot and Galzin (1, p. 133) is peculiar, for it has been recorded from Borneo, Ceylon, Cuba, Malacca, Venezuela, and in addition in Belgium, Germany, Italy, and the mines of Hungary and Saxony.

It is not related to any species of the genus considered in this paper, differing especially in the peculiar cystidia and minute spores, but is placed in its present position more as a matter of convenience in that it possesses a pallid context and hyaline smooth spores.

12. **Polyporus dichrous** Fries, *Syst. Myc.*, vol. 1, p. 364, 1821.

(Fig. 12.)

*P. nigropurpurascens* Schw., *Trans. Am. Phil. Soc.*, p. 360, 1834.

*Poria cruentata* Mont., *Ann. Sci. Nat.*, ser. 3, vol. 16, no. 362, 1851.

*Gloeoporus candidus* Speg., *Anal. Soc. Cien. Arg.*, vol. 16, no. 56, 1883.

*Polyporus Curreyanus* Berk. in *Herb.*; Cke., *Grev.*, vol. 15, p. 20, 1886.

*Leptoporus dichrous* (Fr.) Quel.; *Fl. Myc.*, p. 388, 1888.

*Gloeoporus dichrous* (Fr.) Bres., *Hedw.*, vol. 53, p. 74, 1914.

Pileus effused-reflexed, dimidiate, often imbricate, frequently resupinate, often laterally confluent when covering considerable areas; 1.3 x 2.15 cm. x 1.4 mm.; surface tomentose, often spongy, obscurely zoned, white, becoming dingy cream to isabelline or even darker, margin smooth and more pallid; context white to pallid ochraceous, thin, 0.5-2 mm., soft but firm; tubes and subhymenial tissue distinct from the context, soft gelatinous and readily peeling away in fresh specimens, hard, horny and darker in colour when old, at first white and translucent, changing to flesh colour (save for the more pallid, sterile margins) at maturity; in old specimens often dark reddish or purple-brown, subglobose, 4.6 to mm.; cystidia absent; spores cylindrical, often allantoid, 4.6 x 1.15 mm., hyaline, smooth, abundant.

Habitat: On dead wood and stumps in the forest.

Weraroa, Wellington; July, 1919; *G.H.C.*

Weraroa, Wellington; May, 1925; *J. C. Neill!*

Riccarton, Canterbury; Jan., 1927; *D. W. McKenzie!*

Distribution: Europe; North and South America; South Africa; Japan; Australia; New Zealand.

An abundant species with a penchant for growing on decayed upright stumps, burnt logs and the like in recent forest clearings over which fire has been passed. Although not readily noticeable in dried material, the whole tube layer is markedly distinct from the context. In fresh plants it is quite gelatinous, and may be peeled readily from the context. On account of this diverse nature of the tube layer, the genus *Gloeoporus* is maintained by certain workers, containing this and several related species. Although a good generic character, it has not been considered advisable to separate this under a distinct genus from the few species of *Polyporus* known to occur in New Zealand, as thereby classification is simplified. It will suffice, in this paper at least, to call attention to this feature, and to the fact that the plant is by many placed in *Gloeoporus*.

Although abundant in the Dominion, it appears to be rare in Australia, for Cleland and Cheel (4, p. 530) record but one collection in their possession; and according to Lloyd, though abundant in the United States, it is rare in Europe.

It is one of the anomalous species which has no close relationship with other species of the genus, and is therefore placed in the present position because of its dimidiate, often imbricate nature, light colour of the context, and smooth hyaline spores.

13. **Polyporus Eucalyptorum** Fries, *Pl. Preiss*, vol. 2, p. 135, 1847.  
(Figs. 13-15.)

*P. hololeucus* Kalch., *Hedw.*, vol. 15, p. 114, 1876.

*P. leucocreas* Cke., *Grev.*, vol. 8, p. 55, 1879.

*Polystictus hololeucus* (Kalch.) Sacc., *Syll. Fung.*, vol. 6, p. 241, 1888.

? *Polyporus Hauslerianus* P. Henn., *Hedw.*, vol. 35, p. 305, 1895.

*P. spermolepidis* Pat., *Bull. Soc. Myc. Fr.*, vol. 14, p. 153, 1898.

*Xylostoma gigantea* Cheel, *Proc. Linn. Soc. N.S.W.*, vol. 35, p. 308, 1910.

*Polyporus maculatissimus* Lloyd, *Myc. Notes*, p. 1113, 1922.

Pileus ungulate, often bell-shaped, sometimes applanate, attached by an elongate, lateral or apical, stipe-like base, up to 20 cm. diam., irregular in size and shape; exterior covered with a thin, tough, honey-coloured or umber, minutely villose cuticle, which may be even, obscurely radially and concentrically zoned, or broken up into irregular squamules; context snow white when fresh, isabelline when old, soft, punky-friable and brittle; tubes even, honey coloured or reddish-brown (depending on the age of specimens), distinct and readily separable from the context, 1-3 to mm., angular, dissepiments thin, entire; cystidia absent; spores subglobose, 7-8 x 6-7 mmm., hyaline, smooth, abundant.

Habitat: On living *Nothofagus fusca* trunks.

York Bay, Wellington; July, Sept., 1921; Apl., 1926; *G.H.C.*

Day's Bay, Wellington; Nov., 1926; *D. W. McKenzie!*

State Forest Reserve, Rotorua, Auckland; *Unknown Collector!*

Distribution: Australia; New Zealand.

The largest species of the genus present in New Zealand. It may readily be recognized by the large extent of white, punky context, the readily separable tube layer, and large hyaline, smooth spores. In certain Australian forms, according to Cleland and Cheel (4, p. 523), the spores are slightly larger.

The plant is strictly an annual, and falls from the tree to the ground shortly after it has reached maturity. There it becomes waterlogged, discoloured, and may readily be mistaken for quite a different species. Although placed in the sessile section, the plant usually possesses a short, stipe-like projection serving as a point of attachment. If this structure is lateral, the plant often appears applanate, if apical it assumes a bell-shaped appearance, or if pressed against the trunk of the host, it becomes ungulate. The margins may be entire or even, lobed or crenulate. The surface, also, is by no means constant, and may be smooth, squamulose, or tomentose, and range in colour from

honey-yellow to umber, according to age. It is the cause of a serious heart-rot of beech (*Nothofagus* spp.) in the Wellington Province.

According to Lloyd (12, p. 298) the species closely resembles *P. betulinus*, so much so that separation is possible only on the characters of the spores, those of the latter being cylindrical, 6 x 2.5 mm., whereas those of *P. Eucalyptorum* are subglobose, 7-8 x 6-7 mm. Judging from the description, such as it is, *Polyporus Hauslerianus* might be a synonym of this species, though listed by Lloyd as a *Fomes*.

*P. Eucalyptorum* is not related to any other species of the genus present in New Zealand, but is placed in its present position because of the white context, hyaline smooth spores, and readily separable tube layer. In this last character it resembles *P. dichrous*, but the resemblance is slight, for although in both the tubes are separable from the context, in *P. dichrous* they are of an entirely different consistency, whereas in *P. Eucalyptorum* they are of similar consistency to the context.

14. ***Polyporus proprius*** Lloyd, *Myc. Notes*, p. 1328, 1924.

(Figs. 16, 17.)

Pileus appanate, dimidiate, imbricate, 7-10 x 8-12 x 1-2.5 cm.; surface pallid yellow brown, or yellowish, obscurely zoned or not, radiately sulcately grooved, or not, areolate, tuberculate, delicately tomentose or pruinose, margin even, thick, (5 mm.) rounded; context isabelline, 10 mm. thick, hard and tough, compact; tubes very short, 0.5-1 mm., concolorous, 2-3 to mm., margin sterile, isabelline, angular, oval or round, dissepiments thick, entire, hard and firm; cystidia absent; spores subglobose, hyaline, 5-7 x 5-6 mm., coarsely echinulate, abundant.

Habitat: On dead upright stumps in the forest.

Botanical Gardens, Wellington; March, 1927; *G.H.C.*

Distribution: Endemic.

A species readily recognized by its growth habit, and especially by the hyaline verruculose spores, and thick dissepiments of the short tubes. The colour, too, is characteristic.

The spores closely resembles those of *P. Berkeleyi*, but the plant is separated from this species by its sessile nature, and especially by the different tubes; in *P. Berkeleyi* they are laterally compressed and with thin dissepiments. Apart from its sessile habit, it is most closely related to *P. Berkeleyi* in the colour and structure of the context and nature of the spores, thus tending to show that separation of species on the presence or absence of a stipe is purely artificial, and does not show structural relationships.

15. ***Polyporus gilvus*** (Schweinitz) Fries, *Elench. Fung.*, p. 104, 1828.  
(Fig. 18.)

*Boletus gilvus* Schw., *Schr. Nat.-Ges. Leipzig*, vol. 1, p. 96, 1822.

*Polyporus holosclereus* Berk., *Ann. Nat. Hist.*, vol. 3, p. 324, 1839; non Fries 1838.

*P. cupreus* Berk., *Ann. Nat. Hist.*, vol. 3, p. 393, 1839.

- P. omalopilus* Mont., *Pl. Cell. Cuba.*, p. 423, 1842.  
*P. inamomeus* Mont., *Ann. Sci. Nat.*, ser. 2, vol. 18, p. 20, 1842.  
*P. isidioides* Berk., Hook. *Jour. Bot.*, vol. 2, p. 415, 1845.  
*Trametes pertusa* Fr., Wahl. *Fungi Natal.*, p. 10, 1848.  
*Polyporus carneofulvus* Berk.; Fr., *Nov. Symb.*, p. 68, 1851.  
*P. Laurencii* Berk., *Fl. Tas.*, vol. 2, p. 254, 1860.  
*P. ilicincola* Berk. et Curt., *Grev.*, vol. 2, p. 35, 1873.  
*P. breviporus* Cke., *Grev.*, vol. 12, p. 7, 1883.  
*P. Balsanae* Speg., *Anal. Soc. Cient. Arg.*, vol. 16, No. 42, 1883.  
*Polystictus purpureofuscus* Cke., *Grev.*, vol. 15, p. 24, 1886.  
*Placodes fucatus* Quel., *Ass. Fr.*, p. 4, 1886.  
*Fomes inamomeus* (Mont.) Sacc., *Syll. Fung.*, vol. 6, p. 191, 1888.  
*F. holosclereus* (Berk.) Sacc., *l.c.*, p. 193.  
*F. rubiginosa* (Berk.) Sacc., *l.c.*, p. 194.  
*Polystictus cupreus* (Berk.) Sacc., *l.c.*, p. 272.  
*P. Balsanae* (Speg.) Sacc., *l.c.*, p. 277.  
*Fomes homalopilus* (Mont.) Sacc., *l.c.*, p. 204.  
*Polyporus aureomarginatus* P. Henn., *Bot. Jahrb.*, vol. 22, p. 72, 1895.  
*Phellinus gilvus* (Schw.) Pat. *Essai Tax. Hymen.*, p. 82, 1900.  
*Hapalopilus gilvus* (Schw.) Murr., *Bull. Torr. Bot. Cl.*, vol. 31, p. 418, 1904.  
*Polyporus pseudogilvus* Lloyd, *Myc. Notes*, p. 940, 1920.  
*Fomes gilvus* Lloyd, *Myc. Notes*, p. 1157, 1922.  
*Polyporus gilvo-rigidus* Lloyd, *Myc. Notes*, p. 1334, 1925.

Pileus applanate, dimidiate, sometimes imbricate, 2.7 x 5-12 x 0.5-2 cm.; surface bay to umber, obscurely zoned, radially striate, covered with rough hispid hairs, sometimes spongy-nodose, with a broad, almost glabrous margin, which is thin, entire, and not or only slightly incurved when dry; context fulvus to ferruginous, 2-6 mm. thick, sometimes obscurely zoned, tough and sub-woody; tubes ferruginous to cinnamon, often stuffed, 2-10 mm. long, sometimes stratosed, when with layers of context between strata, deep ferruginous to umber below, 4-8 to mm., round or angular, dissepiments thin and entire; setae abundant, ventricose, acuminate, chestnut brown; spores elliptical or obovate, 4.5 x 2.5-3.5 mm., hyaline, smooth, sparse.

Habitat: On fallen trunks in the forest.

Weraroa, Wellington; Sept. 1919; *G.H.C.*: May 1923; J. C. Neill—*G.H.C.* (3 abundant collections).

Lake Horowhenua, Wellington; May 1919; *G.H.C.*

Hokitika, Westland; Apl. 1923; *F. J. Perham!*

Invercargill, May 1924; *J. B. Cleland!*

Distribution: Britain; Europe; North and South America; Tropics generally; Australia; New Zealand.

Characterized by the applanate shape, fulvus or ferruginous context, abundant coloured setae and hyaline spores.

Probably this species is one of the most frequently misnamed in literature, as the synonymy shows. It varies to a considerable extent, particularly in the characters of the surface, ranging from smooth to

strongly hirsute and tuberculate forms; but as all intermediate stages are now known, it is not possible to maintain most of these, even as forms.

One of the chief characters of the species is its hyaline spores. Yet although hyaline spores are present in all the New Zealand collections, these have when sent abroad, been referred to *P. fulvo-melleus*, a plant with coloured spores.

Furthermore, in certain localities, chiefly the Tropics, the tubes occasionally become stratose, when the plant becomes a *Fomes*, a condition present in several specimens at hand. And structurally it could be equally well be placed in *Fomes*, as it possesses many characters in common with species of this genus, as the hard and subwoody nature of the context, applanate shape, and ventricose setae. But this arrangement could be equally well applied to *P. radiatus*, which to the writer's knowledge, does not at any time have its tubes in strata. As the plant is almost universally referred to *Polyporus*, the writer has also placed it under this genus. Such forms tend to confirm the belief that *Fomes* should be absorbed under *Polyporus*, or else maintained on other characters.

Cleland and Cheel (4, p. 534) record this species for Australia, but note that the spores are yellow-brown. Although their collections have been named by Lloyd, it is evident their species is *P. fulvo-melleus*, for this species is separated only on the coloured spores, in all other characters strongly resembling certain forms of *P. gilvus*. The plant has recently been collected in Western Australia by Mr. W. Carne, who has kindly forwarded specimens.

16. **Polyporus tabacinus** Montagne, *Ann. Sci. Nat.*, ser. 2, vol. 3, p. 349, 1835. (Figs. 19, 20.)

*Polyporus microcycclus* Lev., *Ann. Sci. Nat.*, ser. 3, vol. 2, p. 188, 1844.

*Polystictus tabacinus* (Mont.) Fr., *Nov. Symb.*, p. 93, 1851.

*Polyporus xerampelinus* Kalch., *Grev.*, vol. 4, p. 72, 1876.

*Polystictus microcycclus* (Lev.) Sacc., *Syll. Fung.*, vol. 6, p. 227, 1888.

*P. xerampelinus* (Kalch.) Sacc., *l.c.*, p. 282.

*Inonotus corrosus* Murr., *Bull. Torr. Bot. Cl.*, vol. 31, p. 598, 1904.

Pileus applanate, dimidiate, imbricate, 2.3 x 2.6 cm. x 1.3 mm., incurved and rigid when dry; surface tobacco brown, concentrically zoned, imperfectly radially striate, finely silky-tomentose, margins yellowish or tawny; context umber, firm, 0.5-1.5 mm. thick; tubes even, round, umber, concolorous with context, 1.2 mm. long, 7-8 to mm., dissepiments entire, thin; setae abundant, deep chestnut, acuminate pointed; spores obvate or subglobose, 2.5 x 1.5 mm., hyaline, smooth, rare.

Habitat: On dead logs in the forest.

Day's Bay, Wellington; 1908; *A. H. Cockayne*!

Weraroa, Wellington; July 1919; *G.H.C.*: May 1923; *J. C. Neill—G.H.C.*

Fig. 1.

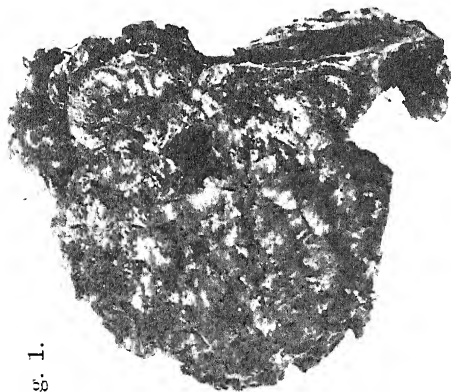


Fig. 2.

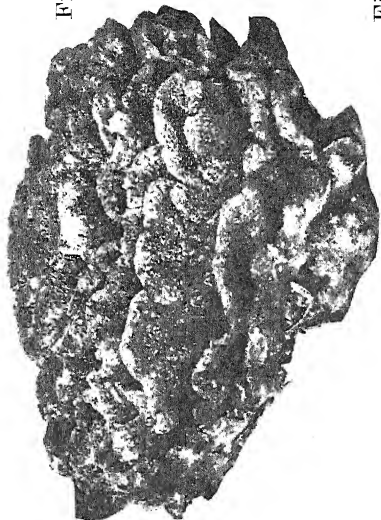


Fig. 3.

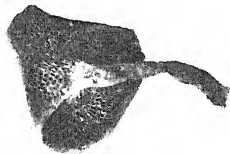


Fig. 4.

- FIG. 1.—*Polyporus Colensoi*, x 1/2. Note the compound pileoli on a common stipe. In certain Australian forms the pileoli are much larger, more loosely aggregated, and attached to a lateral stipe.
- FIG. 2.—*Polyporus rossettus*, x 1/3. Compound pileoli. Australian specimen kindly loaned by Dr. J. B. Cleland, Adelaide.
- FIG. 3.—*Polyporus oblectatus*, natural size. Double plant on the left, plant with lateral stipe in the centre, immature plant on the right.
- FIG. 4.—*Polyporus arcularius*, x 2/3. The central stipe and hexagonal tubes are well shown in this photograph.

Fig. 5.



Fig. 6.

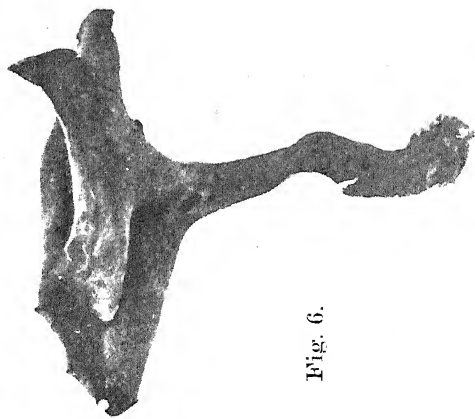
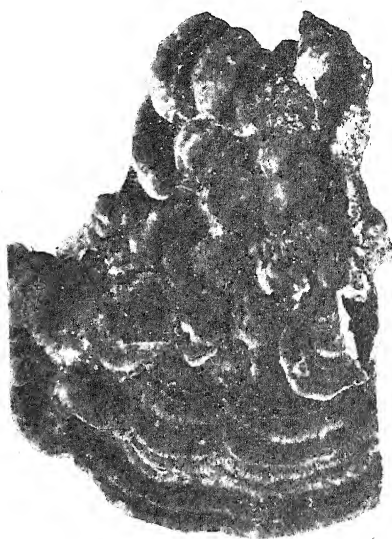


Fig. 7.



Fig. 8.



- FIG. 5.—*Polyporus catenatus*, x 3. Several pilei aggregated together. Note the short stipes, sulcate exterior and pendent habit.
- FIG. 6.—*Polyporus michenopus*, x  $\frac{2}{3}$ . Note the prominent central stipe of this specimen.
- FIG. 7.—*Polyporus michenopus*, x  $\frac{1}{3}$ . Surface and ventral views of laterally stipitate plants. Black cuticular covering to the stipe shown on plant on the right.
- FIG. 8.—*Polyporus hirsutus*, natural size. Note the strongly zoned hirsute surface of the pileus.

Fig. 9.

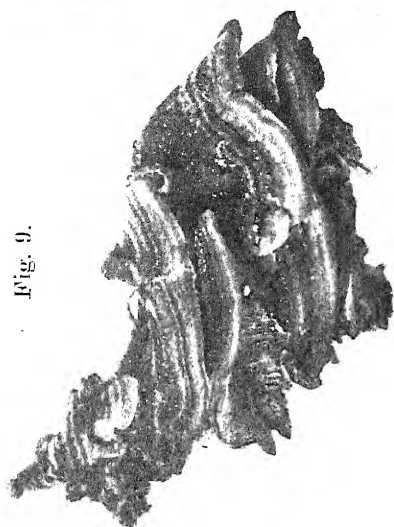


Fig. 10.



Fig. 12.

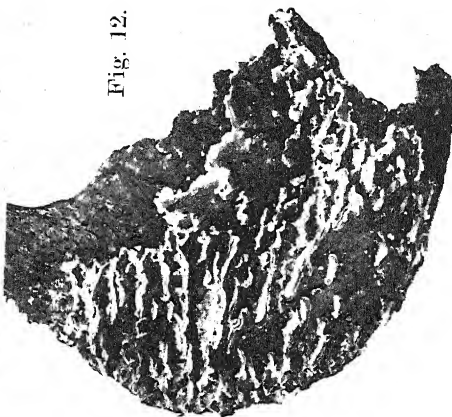


Fig. 11.



FIG. 9.—*Polyporus versicolor*, x  $\frac{2}{3}$ . Note the strongly zoned pileus and imbricate habit.  
 FIG. 10.—*Polyporus adustus*, x  $\frac{1}{2}$ . Pileate form on the left, resupinate form on the right.  
 FIG. 11.—*Polyporus versicolor*, natural size. Gibbous forms; contrast with Fig. 9.  
 FIG. 12.—*Polyporus dichrous*, x  $\frac{1}{2}$ . On bark of dead *Pinus* log. Note the imbricate habit.



Fig. 13.

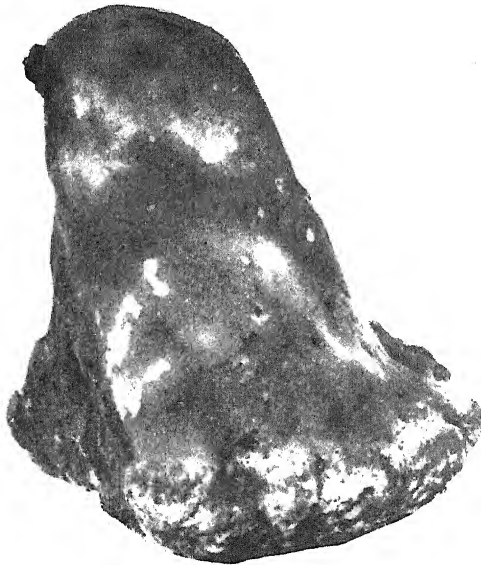


Fig. 14.

- FIG. 13.—*Polyporus Eucalyptorum*, x  $\frac{1}{3}$ . Bell-shaped specimen; point of attachment on top left. White areas are where cuticle has been removed by insects.
- FIG. 14.—*Polyporus Eucalyptorum*, x  $\frac{1}{4}$ . Ungulate specimen. Point of attachment on top left. Plant flattened where it came in contact with the trunk of the host.

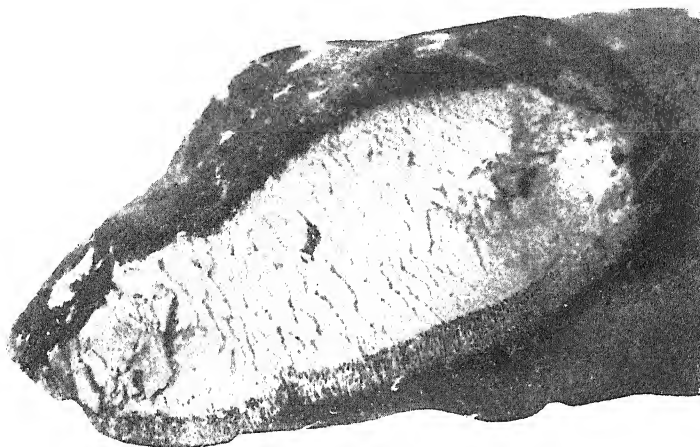


Fig. 15.

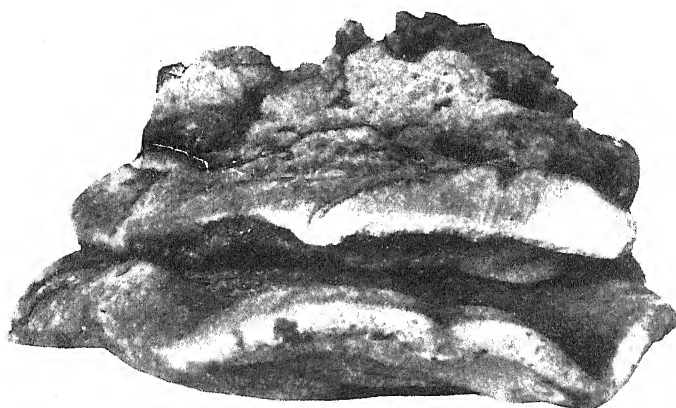


Fig. 16.

- FIG. 15.—*Polyporus Eucalyptorum*, x  $\frac{2}{3}$ . Applanate specimen. Showing the white context and separable tube layer.
- FIG. 16.—*Polyporus proprius*, x  $\frac{1}{2}$ . Two superposed pilei, upper sectioned to show the thick context and thin tube layer.



Fig. 17.



Fig. 18.

FIG. 17.—*Polyporus proprius*, natural size. Ventral surface showing the broad sterile margin and thick walls of the tubes.

FIG. 18.—*Polyporus gilvus*, x 1/2. Surface view showing its roughened nature, applanate shape of pileus, and broad point of attachment.

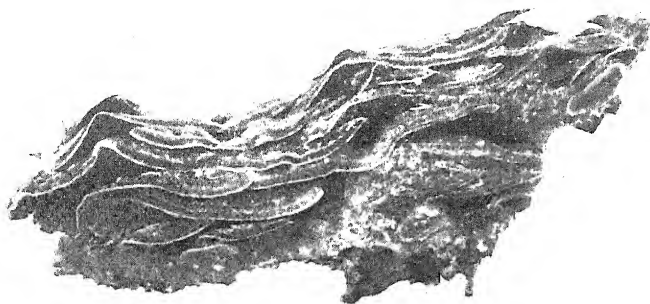


Fig. 19.



Fig. 20.

FIG. 19.—*Polyporus tabacinus*, x  $\frac{2}{3}$ . Showing the imbricate nature of the pilei.

FIG. 20.—*Polyporus tabacinus*, x  $\frac{2}{3}$ . Surface view showing the strongly zoned surface of the pilei and bright coloured margins.

All photographs taken by H. Drake and the writer conjointly.



Distribution: South America; Africa; East Indies; Australia; New Zealand.

The species is characterized by the tobacco-brown colour of the whole plant, the usually silky zoned pileus, umber context, and abundant setae. Spores have been found attached to basidia in only one collection. These are exceedingly minute, so that one was at first inclined to believe they were immature, but as they agree with detached spores in the same field, they may be considered as being of this size. They are apparently rare, as so few records of their appearance have been published.

17. *Polyporus radiatus* (Sowerby) Fries, *Syst. Myc.*, vol. 1, p. 269, 1821.

*P. cucullatus* Berk. et Curt., *Grev.*, vol. 1, p. 51, 1872.

*P. glomeratus* Peck, *Ann. Rept. N.Y. State Mus.*, vol. 24, p. 78, 1873.

*Inonotus radiatus* (Sow.) Karst., *Rev. Myc.*, vol. 3, p. 19, 1881.

*Polyporus scrobiculatus* Karst., *Medd. Soc. Faun. et Fl. Fenn.*, p. 50, 1883.

*Inodermus radiatus* (Sow.) Quel., *Fl. Myc.*, p. 392, 1888.

*Polytictus radiatus* (Sow.) Sacc., *Syll. Fung.*, vol. 6, p. 247, 1888.

*P. scrobiculatus* (Karst) Sacc., *l.c.*

*Polyporus aureonitens* Pat. et Peck, *Ann. Rept. N.Y. State Mus.*, vol. 42, p. 25, 1889.

*Poria setigera* Peck, *Ibid.*, vol. 51, p. 293, 1898.

*Xanthochrous radiatus* (Sow.) Pat., *Ess. Tax. Hymen.*, p. 100, 1900.

*Polyporus radians* Lloyd, *Myc. Notes*, p. 1186, 1923; *nomen nudum*.

Pileus imbricate, fan-shaped or dimidiate, often resupinate, 1-3 x 2-7 x 0.25-1 cm.; exterior obscurely radially and concentrically striate, usually glabrous, but in young plants finely tomentose, fulvus to deep umber; context thin, 1-2 mm. or less, ferruginous to umber, in old specimens almost black, sometimes obscurely zoned; tubes 2-4 mm. long, cinnamon, angular, 4-5 to mm., dissepiments thin, brittle, often lacerate; cystidia abundant, ventricose, acuminate, chestnut brown; spores subglobose or shortly elliptical, 4-6 x 3-4 mmm., smooth, pallid ferruginous, abundant.

Habitat: On fallen *Nothofagus* spp. trunks in forest.

Queenstown, Otago; December 1919; *G.H.C.*

York Bay, Wellington; June 1922; *E. H. Atkinson!*

Canterbury; February 1881; *T. Kirk!*

Distribution: Britain; Europe; North America; Australia; New Zealand.

The almost glabrous, dark, radically and concentrically striate pileus, dark brown thin context, setae and coloured spores are the characters of the species.

Confusion exists in literature as to the colour of the spores of this species. Lloyd (12, p. 351) states that they are hyaline, and that those plants with coloured spores should be placed under *P. cuticu-*

*laris*, which closely resembles *P. radiatus* in other characters. Murrill (16, p. 90) places the species in *Ionotus*, a "genus" with coloured spores, and describes these as being "luteolus"; Bourdot and Galzin (1, p. 199) state that the spores are "puis brunies dans les tubes . . . en masse: blanches, creme ou blanc jaunatre." In a footnote they remark: "Les spores en masse sur feuilles, ecorces, varient de blanc jaunatre; si elles sont tombees sur un chapeau de *radiatus* humide, elles se teignent en jaune ou fauve, ce qui explique qu'il y ait souvent des spores colorees, a l'interieur des tubes." Rea (17, p. 586) records them as white. Yet numerous genera in the family have been based on the colour of the spores!

Doctors Weir and Lloyd have both determined collections forwarded to them as being *P. radiatus*, despite the coloured spores: so the writer is apparently justified in considering the collections listed are of *P. radiatus*, and the spores coloured.

Cleland and Cheel (4, p. 535) doubtfully record the presence of the species in Australia on one plant doubtfully identified as this species by Lloyd. Cooke (5, p. 146) also records it from Australia.

These last three species form a small natural group characterized by the deeply coloured context, tough nature of the pileus, and presence of ventricose setae.

## LITTLE KNOWN, DOUBTFUL AND EXCLUDED SPECIES.

Between the 'Forties and 'Eighties of last century numerous fungi were collected by such early botanists as Colenso, Hooker, Travers, Lindsay and Kirk. These were for the most part despatched to herbaria abroad—chiefly Kew—where they were named, and new species "described." As these collectors were not Mycologists but merely collected any fungi sufficiently large to attract their attention, it will be seen that the majority of their collections consisted of Polypores, Agarics and similar large species. They were forwarded, without field notes, usually imperfectly preserved, and mostly without selection to give the range of characters, etc.—most, in fact, being single specimens—to Mycologists of the period who for the most part entertained a fixed belief that any species from a new country must necessarily be new, and in addition were invariably overworked, few at that period possessing a knowledge of systematic Mycology. Consequently the greater part of these earlier collections were misdetermined, and many named as new species. Lists were published—chiefly by Colenso—in earlier numbers of this periodical. Types were sometimes kept at Kew, but many have disappeared subsequently; and as the descriptions drawn up at that period were so scanty as to be worthless for diagnosis, and seldom accompanied by an illustration, it is obvious that determination of most of these early records is a matter of conjecture. Unwittingly, therefore, these earlier workers have set the most difficult problem that any systematist is confronted with—the determination without adequate material of the species recorded for his region.

The fallacy of incorporating these dubious records in the flora of this Dominion, in the absence of authentic specimens, is obvious. It

is made more apparent by the fact that of all these earlier records, not one specimen exists in New Zealand to-day. Mr. W. R. B. Oliver, at the request of the writer, has searched through the late Rev. W. Colenso's herbarium, kept at the Dominion Museum, and reports the total absence of any mycological specimens. He further stated that even were specimens present, they would have been valueless, for in this herbarium plants were tied in packages bearing a number only—no name, date or locality reference being appended. The numbers may at one time have had a value, as there may possibly have been in existence a list, but this is now wanting.

The following have been recorded by various workers as having been collected in New Zealand, but in the absence of authentic specimens, the writer is not disposed to accept their validity. Doubtless further collections will come to hand, from time to time, when they will be dealt with in subsequent papers.

(a) *Polyporus atristrigosus* Lloyd, *Myc. Notes*, p. 731, 1917. Recorded by Lloyd (*Letter 66*, p. 6, 1917) as being collected by W. A. Scarfe.

(b) *P. aureo-fulvus* Lloyd, *Myc. Notes*, p. 1108, 1922. This will be considered in a subsequent paper under *Trametes*, for it belongs to this genus as now defined.

(c) *P. borealis* Fries, *Syst. Myc.*, vol. 1, p. 366, 1821. Recorded by Massee (14) as occurring here.

(d) *P. cinnabarinus* Fries, *Syst. Myc.*, vol. 1, p. 371, 1821. Recorded by Massee (14) as *Polystictus*, from New Zealand. It is an abundant species, and will be considered under *Trametes*, to which genus it belongs.

(e) *P. citreus* Berk., *Jour. Linn. Soc.*, vol. 13, p. 162. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 28, p. 614, 1895) as *Polystictus*, as being collected by him in Hawke's Bay. It is a synonym of *Poria vaporaria* Fr.

(f) *Polystictus conchifer* (Schw.) Cke., *Grev.*, vol. 14, p. 79, 1886. Recorded by Miss Wakefield (18, p. 364) as being collected at Rotorua by Mr. W. N. Cheesman.

(g) *Polyporus dictyopus* Montagne, *Ann. Sci. Nat.*, ser. 2, vol. 3, No. 14, 1835. Recorded by Lloyd (*Myc. Notes*, p. 1296, 1924) as having been collected by Jas. Mitchell. Lloyd has also determined for the writer a collection as above; but this was typically *P. melanopus*.

(h) *P. diffusus* Berkley, *Fl. N.Z.*, vol. 2, p. 180, 1855. An endemic species described by Berkeley from specimens forwarded to Kew by Colenso. Massee (14) states that there are no specimens at Kew, but that the description shows it should be placed under *Poria*. As no specimens exist, and as the description is too imperfect to allow of its being recognised if again encountered, the name should be removed from literature.

(i) *P. Drummondii* Klotzch, *Linnaea*, vol. 8, p. 487, 1833. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 25, p. 340, 1892) as being collected by himself. It is probably a misdetermination of *P. hirsutus*.

(j) *P. exiguus* Colenso, *Trans. N.Z. Inst.*, vol. 17, p. 266, 1884. *P. exiguus* Cke., *Grev.*, vol. 15, p. 23, 1887. Recorded as a new species by Colenso, but unaccompanied by a valid description, consequently

a *nomen nudum*. Therefore, whether Cooke's specimen is a valid species or not, it cannot be listed under this specific name.

(k) *P. gramocephalus* Berkeley, Hook. *Lond. Jour. Bot.*, vol. 1, p. 148, 1842. Collected and forwarded by Colenso to Kew, where it was described by Berkeley. A subsequent record was published by Colenso in *Trans. N.Z. Inst.*, vol. 23, p. 393, 1890, but whether on a diagnosis made by himself or Kew authorities is not stated.

(l) *P. hypomelanus* Berkeley in Herb.; Cke. *Grev.*, vol. 15, p. 51, 1886. Known only from the type, now at Kew, collected by Colenso.

(m) *Polystictus imbricatus* Lloyd, *Myc. Notes*, p. 791, 1918. Recorded by Lloyd (*Myc. Notes*, p. 1123, 1922) as being collected by Miss H. K. Dalrymple and (l.c., p. 1127) by W. A. Scarfe. *Polyporus imbricatus* Fr. antedates this by many years, so that even if the species is a valid one (which it is impossible to judge from the scanty and incomplete description given by Lloyd) the specific name *imbricatus* cannot be used. It is interesting to note that Rea (17, p. 582) gives *P. sulphureus* (also recorded from New Zealand) as a synonym of *Polyporus imbricatus*.

(n) *Polyporus iodinus* Montagne, *Ann. Sci. Nat.*, ser. 2, vol. 16, p. 108, 1841. Recorded by Lloyd (*Letter 47*, p. 3, 1913) as *Polystictus*, as being collected by S. Duncan. Most certainly a misdetermination of *P. tabacinus* Mont.

(o) *P. lactus* Cooke, *Grev.*, vol. 12, p. 16, 1883. *P. lactus* Mass., *Trans. N.Z. Inst.*, vol. 39, p. 6, 1906. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 23, p. 393, 1890) as being collected in Hawke's Bay. Probably a misdetermination of *P. Berkeleyi*.

(p) *P. lentus* Berkeley, *Outl. Brit. Fung.*, p. 237, 1860. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 19, p. 303, 1886) as being collected by himself in Hawke's Bay. A misdetermination of *P. arcularius*.

(q) *Polystictus lilacino-gilvus* (Berk.) Cke., *Grev.*, vol. 14, p. 82, 1886. Recorded by Miss Wakefield (18, p. 364) as being collected in New Zealand. According to Lloyd (11, p. 226) this is a *Trametes*.

(r) *Polystictus luteo-olivaceus* (B. et Br.) Cooke, *Grev.*, vol. 14, p. 86, 1886. Recorded by Miss Wakefield (18, p. 365) as being collected by Cheesman at Mamaku, near Rotorua.

(s) *Polyporus nivicolor* Colenso, *Trans. N.Z. Inst.*, vol. 16, p. 361, 1883. According to Lloyd (10, p. 147) this is a synonym of *P. phlebophorus* Berk.

(t) *P. occidentalis* Klotzsch, *Linneaea*, vol. 8, p. 486, 1833. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 28, p. 614, 1895) as being collected by himself. Also recorded by Lloyd (*Myc. Notes*, p. 1320, 1924) as being collected at Napier by H. Hill.

(u) *Polystictus ochraceus* (Pers.) Lloyd, *Letter 65*, p. 11, 1917, *nomen nudum*. Recorded by Lloyd (l.c.) as being collected by W. E. Barker. As the name was unaccompanied by a description, it must be removed from the literature.

(v) *Polystictus pergamenus* Fries, *Epi.*, p. 480, 1838. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 19, p. 308, 1886) as being collected by himself in Hawke's Bay.

(w) *Polyporus petaloides* Fries, *Hym. Eur.*, p. 536, 1874. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 19, p. 303, 1886) as being collected by himself.

(x) *P. phlebobothrus* Berkeley, *Fl. N.Z.*, vol. 2, p. 177, 1855. An endemic species described by Berkeley from material forwarded to Kew by Colenso. Later collected and renamed as *P. nivicolor* by Colenso.

(y) *P. picipes* Fries, *Syst. Myc.*, vol. 1, p. 353, 1821. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 19, p. 303, 1886) as being collected by himself. Probably a misdetermination of *P. melanopus*.

(z) *Polystictus pinisitus* Fries, *Elench. Fung.*, p. 95, 1828. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 28, p. 614, 1895) as being collected by himself. Lloyd (*Myc. Notes, Poly. Issue*, No. 2, p. 27, 1909) states that this record is based on an error of determination.

(aa) *Polyporus plebius* Berkeley, *Fl. N.Z.*, vol. 2, p. 179, 1855. Named by Berkeley from material collected in New Zealand. According to Bresadola (2, p. 235), "*P. plebejus* Berk. typus ex New Zealand amplius non adest. Subtypus ex Himalaja, qui cum diagnosi berkeleyana typi bene convenit, est cum *Fomite luzonensi* Murr. et *F. semitosto* B. identicus. *Polyporus plebejus* Berk. Fungi Bras. No. 15, 69, 100 est *Fomes supinus* Sw."

Lloyd (11, p. 227) records it under *Trametes plebia*, and gives a description drawn up from the Himalayan specimens. As Berkeley's description is too inadequate to use for diagnostic purposes, and considering Bresadola's remarks, the writer believes the name should be removed from the literature.

(bb) *Polyporus rhipidium* Berkeley, *Hook. Jour. Bot.*, vol. 6, p. 319, 1847. *Favolus rhipidium* (Berk.) Sacc., *Syll. Fung.*, vol. 6, p. 397, 1888. Lloyd (8, p. 24) records this from New Zealand as being among the plants of this species at Kew.

(cc) *P. rigidus* Lloyd, *Myc. Notes*, p. 1319, 1924, *nomen nudum*. Published (*l.c.*, p. 1334) as *P. gilvo-rigidus* Lloyd, n. sp. By the writer it is considered a synonym of *P. gilvus*. In any case the name *rigidus* is preoccupied = *P. rigidus* Lev. 1844.

(dd) *Polystictus sanguineus* Fries, *Nov. Symb.*, p. 75, 1881. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 23, p. 395, 1890) as having been collected in New Zealand. It is a synonym of *Trametes cinabarina* Fr.

(ee) *Polyporus scruposus* Fries, *Epi.*, p. 473, 1838. Recorded for New Zealand by Massee (14). This is a synonym of *P. gilvus*.

(ff) *Polyporus scutiger* Kalchbrenner. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 23, p. 393, 1890) as being collected by himself. Lloyd (10, p. 162) states that the name was changed by Fries to *P. Kalchbrenneri*, and was based on a small specimen of *P. tomentosus*.

(gg) *Polystictus sector* Fries, *Epi.*, p. 480, 1838. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 23, p. 395, 1890) as being collected by himself.

(hh) *Polyporus setiger* Cooke, *Grev.*, vol. 19, p. 1, 1890. Known only from the type specimen at Kew. Probably *P. scutiger* is a misspelling of this name. Lloyd states (12, p. 375) that *P. atrostrigosus*, also from New Zealand, but known from scanty material, is very similar, and probably the same species. He records a collection (*Letter 68*, p. 7, 1919) from W. A. Scarfe.

(ii) *P. squamosus* Fries, *Syst. Myc.*, vol. 1, p. 343, 1821. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 23, p. 393, 1890) as being collected by himself.

(jj) *P. sulphureus* Fries, *Syst. Myc.*, vol. 1, p. 357, 1821. Lloyd records this species (*Myc. Notes*, p. 1189, 1923) as being collected by W. A. Scarfe.

(kk) *Polystictus trizonatus* Cooke, *Grev.*, vol. 12, p. 17, 1883. Lloyd (*Letter 66*, p. 6, 1917) records this as being collected by W. A. Scarfe. It is a synonym of *Polyporus versicolor*.

(ll) *Polystictus velutinus* Fries. Massee (14) records this from New Zealand. It is most probably a misdetermination of *Polyporus versicolor*.

(mm) *Polyporus vulgaris* Fries, *Syst. Myc.*, vol. 1, p. 381, 1821. Recorded by Colenso (*Trans. N.Z. Inst.*, vol. 26, p. 321, 1893) as being collected by himself. It is a *Poria*.

(nn) *P. xerophyllus* Berkeley, *Fl. N.Z.*, vol. 2, p. 178, 1855. Known only from a single specimen at Kew, collected in New Zealand by Colenso.

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## COMBINED FUNGUS AND HOST INDEX TO THE GENERA FOMES AND POLYPORUS.

All synonyms are in italics; the page number on which is a description of the species in question, or host of that species, is also italicized.

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## New Plant Localities.

By ARNOLD WALL.

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by Editor, 5th August, 1927; issued separately,  
8th November, 1927.]

*Gymnogramme rutaefolia* Hook. et Grev., Rocks by Clutha River opposite Cromwell, Otago.

*Ehrharta Thomsoni* Petrie. Goulard Downs, Nelson. A very minute form, probably a distinct var.

*Ehrharta Colensoi* Hook. f. Dore Pass; Lake Te Anau, Otago.

*Agrostis parviflora* R. Brown. Mt. Herbert, Banks Peninsula, Canterbury. In shady spots at c. 2500ft. The first record in Canterbury.

*Agrostis tenella* Petrie. Peak Hill, Lake Coleridge, Canterbury.

*Deschampsia novae-zelandiae* Petrie. Hakatere Station, North Ashburton River, Canterbury; Mt. Pisa, Otago.

*Triodia pumila* Hack. Old Man, Ashburton Mts., Canterbury.

*Danthonia oreophila* Petrie. Mt. Earnslaw, Otago; Copland Pass, Mt. Cook, Canterbury and Westland.

*Trisetum Cheesemanii* Hack. Mt. Cardrona, Otago; Forbes River, Canterbury. This is the first Otago record for this species.

*Poa acicularifolia* Buch. Mt. Alexander, Seaward Kaikouras, Marlborough; Hells Gate, Mason River, Canterbury.

*Poa exigua* Hook f. Alma River, Tairāhema, Nelson; Clarence and Archeron Rivers, Marlborough. Not before recorded north of Mt. Arrowsmith. Ashburton River, Canterbury; Lawrence River, Canterbury.

*Poa dipsacea* Petrie. Staircase Gully, Waimakariri River, Canterbury.

*Poa Maniototo* Petrie. Upper Clarence River, near junction with Acheron River, Canterbury and Marlborough.

*Poa Kirkii* Buch. var. *Collinsii* Hack. Old Man, Ashburton Mts., Canterbury. Hitherto recorded from very few stations.

*Agropyrum aristatum* Cheesem. Old Man, Ashburton Mts., Canterbury; Ben More, Porter's Pass, Canterbury; Ribbonwood Creek, Lake Pearson, Canterbury; Mt. Trovatore, Lewis Pass, Canterbury.

*Asperella gracilis* T. Kirk. Ben More, Head of Selwyn River, Canterbury; Copland Pass, Western side, Westland.

*Uncinia macrolepis* Decne. Mt. Pisa, Otago.

*Carex pyrenaica* Wahl. Mt. Arrowsmith, 6,500ft., Canterbury. Also in very many other localities in the Southern Alps, so numerous that no further record was kept.

*Carex pterocarpa* Petrie. Old Man, Ashburton Mts., Canterbury. This is the first record beyond Otago and extends the range of this plant enormously. (Identified by D. Petrie, 1922.)

- Carex resectans* Cheesem. Ure River, Marlborough; Clarence River, Marlborough. This is the first record in Marlborough. The plant is doubtless common, but is easily overlooked. Hurunui Gorge, Canterbury; Canterbury Plains; Banks Peninsula; New Brighton Dunes.
- Carex leporina* Linn. Mt. Greenland, Ross, Westland.
- Carex lagopina* Wahl. Old Man, Ashburton Mts., Canterbury. The only Canterbury record hitherto is in the Craigieburn Mts. Mt. Cardrona, Otago.
- Carex Berggreni* Petrie. Tarndale, Nelson. Furthest north hitherto is the Upper Waimakariri: Hawdon River, A. Wall; Arthur's Pass, W. Martin and A. Wall.
- Carex Petriei* Cheesem. var. *rubicunda* Kirk. Onetapu Desert, North Island; Clarence River, Marlborough; Lake Lyndon, Canterbury.
- Cladium Gunnii* Hook. f. Mt. Grey, Canterbury. The first record in Canterbury.
- Astelia Petriei* Cockayne. Mt. Sherwood, near Waiau, Marlborough; Copland Pass, Mt. Cook, Canterbury and Westland; Mt. Trevor, Lewis Pass, Canterbury; Mt. Mantell, Nelson.
- Luzula micrantha* Buchen. Mt. Pisa, Otago.
- Luzula ulophylla* Cockayne and Laing. Mt. Roy, Lake Wanaka, Otago; Tasman River, Canterbury.
- Muehlenbeckia ephedrioides* Hook. f. Upper Waiau River, Canterbury; Poulter River, Canterbury; Clarence and Dillon Rivers, Marlborough. These seem to be the first records of this in Alpine regions. Buller River, near Murchison, Nelson. First record west of the Southern Alps.
- Gypsophila tubulosa* Boiss. Clarence River, 2,500ft., Marlborough; Maronan Road, Ashburton, Canterbury (Dr. H. H. Allan!).
- Ranunculus chordorrhizos* Hook. f. Mt. Sinclair, Mesopotamia, Canterbury, c. 6,000ft. A link between the stations at Macaulay River and Mt. Somers.
- Ranunculus tenuicaulis* Cheesem. Hollyford River, Westland; Dore Pass, Lake Te Anau, Otago.
- Ranunculus lappaceus* Smith var. *pimpinellifolius* Benth. Cairn Range and other localities in the neighbourhood of the Upper Selwyn, Canterbury.
- Ranunculus Cheesemanii* T. Kirk. Sloven's Creek, Upper Waimakariri, Canterbury.
- Ranunculus Sinclairii* Hook. f. Mt. Ernest, Makarora, L. Wanaka, Otago.
- Ranunculus gracilipes* Hook. f. Mt. Arrowsmith, 5,000ft., Canterbury. Not before recorded north of Mt. Cook district.
- Caltha obtusa* Cheesem. Mt. Princess, Spenser Mts., Canterbury.
- Myosurus aristatus* Benth. Cairnmuir Range, Clyde, Otago. At c. 3,000ft. forms quite a belt.
- Nasturtium Enysii* Cheesem. Malte Brun, Tasman Glacier, Canterbury.
- Nasturtium fastigiatum* Cheesem. Mt. Skedaddle, Hurunui River, Canterbury.
- Cardamine depressa* Hook. f. Blue Mt., Ure River, Marlborough.

- Sisymbrium novae-zelandiae* Hook. f. Mt. Pleasant, Lyttelton, Canterbury.
- Lepidium tenuicaule* T. Kirk. Coast near Ashburton, Canterbury. (Dr. H. H. Allan!)
- Geum leiospermum* Petrie. Mt. Alexander, Seaward Kaikouras, Marlborough; Mt. Cleughearn, Lake Monowai, Southland; Mt. Oxford, Canterbury.
- Carmichaelia uniflora* T. Kirk. Makarora River, Lake Wanaka, Otago; Eglinton River, Lake Te Anau, Otago.
- Carmichaelia Enysii* T. Kirk. Taylor River, Canterbury. Valleys of the Boyle, Hope and Waiau Rivers, Canterbury.
- Carmichaelia compacta* Petrie. Alexandra, Central Otago.
- Stackhousia minima* Hook. f. Base of Mt. Una, Spenser Mts., Canterbury.
- Drapetes Dieffenbachii* Hook. var. *laxa* Cheesem. Base of Mt. Somers, Canterbury; Rows Hills, Mt. Hutt, Canterbury; Lake Tennyson and Upper Clarence, Canterbury.
- Epilobium Wilsoni* Petrie. Puhipuhi River, Marlborough.
- Epilobium gracilipes* T. Kirk. Lake Tennyson, Canterbury; Goulard Downs, Nelson; Mt. Mantell, Nelson.
- Epilobium brevipes* Hook. f. Puhi Puhi River, Marlborough.
- Epilobium purpuratum* Hook. f. Mt. Earnslaw, Spur north of Earnslaw Creek. This is quite likely the type locality.
- Epilobium tenuipes* Hook. f. Onetapu Desert, North Island.
- Epilobium rostratum* Cheesem. Taylor River, Ashburton Mts., Canterbury; Stour River, Canterbury; Dillon River, branch of Clarence River, Marlborough; Alexandra, Central Otago.
- Epilobium elegans* Petrie. Lake Tennyson, Canterbury.
- Dracophyllum Kirkii* Berggren. Lead Hill, Collingwood.
- Parsonia capsularis* R. Br. var. *parviflorum* Carse. Ure River, Marlborough.
- Convolvulus erubescens* Sims. Hurunui Gorge, Canterbury; Clarence and Acheron Rivers, Canterbury and Marlborough.
- Gentiana gracilifolia* Cheesem. Goulard Downs, Nelson.
- Gentiana Townsonii* Cheesem. Goulard Downs, Nelson; Mt. Mantell, Nelson.
- Gentiana divisa* Cheesem. Heaphy Saddle, Nelson.
- Myosotis angustata* Cheesem. Mt. Halfmoon, Dillon River, at 6,700ft.
- Myosotis explanata* Cheesem. Mt. Moltke, Franz Josef Glacier. The first record on the western side of the Southern Alps.
- Veronica salicifolia* Forst. var. *Kirkii* Cheesem. Ben More, Ure River, Marlborough. Hitherto only recorded in Canterbury.
- Veronica rupicola* Cheesem. Mt. Sherwood, near Waiau, Marlborough.
- Veronica Willcoxii* Petrie. Mt. Una, Spenser Mts., Nelson; Mt. Trovatore, Lewis Pass, Boundary of Nelson and Canterbury. The first record beyond Otago and Westland.
- Veronica tumida* T. Kirk. Raglan Mts., near Tophouse, Nelson.
- Veronica quadrifaria* T. Kirk. Mt. Arrowsmith, 5,000ft., Canterbury.
- Veronica Petriei* T. Kirk. Dore Pass, Lake Te Anau, Otago.
- Veronica linifolia* Hook. f. Kowhai River, Canterbury; Staircase Gully, Canterbury.
- Veronica uniflora* T. Kirk. Mt. Turner, Makarora, L. Wanaka, Otago.

- Coprosma microcarpa* Hook. f. Doubtful Sound.
- Wahlenbergia congesta* N. E. Brown. Coast between Karamea and Heaphy Rivers, Nelson.
- Wahlenbergia Matthewsii* Cockayne. Puhi Puhi River, Marlborough.
- Lobelia linnaeoides* Petrie. Mt. Turner, Makarora, L. Wanaka, Otago.
- Isotoma fluviatilis* F. Muell. Lake Coleridge, Canterbury.
- Selliera radicans* Cav. Hills near Craigieburn, Canterbury; Porter and Broken Rivers, Canterbury.
- Phyllachne rubra* Cheesem. Mt. Pisa, Otago.
- Lagenophora pinnatifida* Hook. f. Ada River, Canterbury.
- Olearia fragrantissima* Petrie. Peel Forest, Canterbury.
- Olearia Haastii* Hook. f. Ribbonwood Creek, L. Pearson, Canterbury; Black Birch Creek, Mt. Cook district, Canterbury; Dillon River, Marlborough.
- Celmisia ramulosa* Hook. f. Leaning Rock, Dunstan Mts., Otago.
- Celmisia brevifolia* Cockayne. Carriek Range, Otago.
- Celmisia petiolata* Hook. f. Kowhai River, Canterbury. It seems desirable to record eastern stations for this species which is so typically western.
- Celmisia linearis* Armst. Malte Brun, Canterbury; Sealy Range, Canterbury.
- Celmisia Macmahoni* T. Kirk. Mt. Fishtail, Nelson. This record was, of course, to be expected.
- Haastia Sinclairii* Hook. f. Old Man, Ashburton Mts., Canterbury.
- Gnaphalium Keriense* A. Cunn. Waimakariri Gorge. Probably the southern limit; very rarely recorded on the eastern side of the Southern Alps. Possibly Dr. H. H. Allan's plant of Rakaia Gorge is this also.
- Raoulia mammillaris* Hook. f. Craigieburn Range, Canterbury; Mt. Somers, Canterbury.
- Raoulia Haastii* Hook. f. Hooker Valley, Canterbury.
- Raoulia Youngii* Beauverd. Mt. Kinsey, Mt. Cook, Canterbury; Ball Spur, Mt. Cook, Canterbury; Malte Brun, Mt. Cook, Canterbury; Mt. Constitution, Makarora, L. Wanaka, Otago.
- Raoulia Hectori* Hook. f. Old Man, Ashburton Mts., Canterbury.
- Raoulia Parkii* Buch. Mt. Arrowsmith, 6,500ft., Canterbury; Mt. Potts, 6,000ft. Not before recorded north of the Mt. Cook district. Hooker River, Canterbury; Mt. Ernest, Makarora, L. Wanaka, Otago.
- Helichrysum Purdiei* Petrie. Mt. Pleasant, Lyttelton, Canterbury. This is the first record in Canterbury.
- Helichrysum dimorphum* Cockayne. Junction of the Porter and Thomas Rivers, Canterbury. This extends the distribution about ten miles in a southerly direction from Puffer's Creek and the Poulter. It is also on the Esk River.
- Cotula pectinata* Hook. f. var. *sericea* T. Kirk. Leaning Rock, Dunstan Mts., Otago.
- Abrotanella caespitosa* Petrie. Mt. Princess, Spenser Mts., Canterbury.

## Some Crevice Plants from the Lava Field at Mt. Wellington.

By JOYCE H. WILSON, M.Sc.

[Read before the Auckland Institute, 9th November, 1926; received by Editor,  
31st December, 1926; issued separately,  
8th November, 1927.]

PLATES 32, 33.

### INTRODUCTION.

*Aspect.*—Although the lava seams run in various directions the majority are in a line roughly from east to west. Trees grow to a great size and appear altogether more luxuriant on the northern side, which is directly exposed to light and warmth, while those on the southern side are dwarfed and straggling. On the southern side crevice plants attain their greatest development, *Astelias* of various species growing in every available position, while *Peperomia* and ferns occupy the smaller crevices and the deep fissures.

*Climate.*—The summer is hot with a fairly low rainfall, while in the winter the rainfall is higher. There is no very great range of temperature. The prevailing westerly and north westerly winds blow from the sea, which is only a few miles away.

*Soil.*—This is formed by the weathering of the rock and the production of humus from decaying plants, especially *astelias*. It lodges in the crevices and in sheltered positions on flat rocks, where it is often held by the matted roots of the ferns *Cheilanthes Seiberi* and *Cyclophorus serpens*. Owing to its fine texture it is well adapted for holding moisture.

*Moisture.*—The relative humidity of the air in the crevices is greater than that outside. Experiments were made under various conditions at the end of winter and in spring, using a wet and dry bulb hygrometer.

(a) Dull day with cold wind—

<i>In open.</i>	<i>In crevice.</i>
Dry bulb 11° C.	10° C.
Wet bulb 9° C.	9° C.
Relative humidity .63	.87

(b) Calm day with bright sunshine—

<i>In open.</i>	<i>In crevice.</i>
Dry bulb 17° C.	13° C.
Wet bulb 14° C.	12° C.
Relative humidity .69	.869

## 1. GENERAL REMARKS ON THE PLANTS OF THE LAVA FIELD.

The plants found are very varied in character, a list being given below.

Ranunculaceae	Loganiaceae
<i>Clematis indivisa</i>	<i>Geniostoma ligustrifolium</i>
Cruciferae	Convolvulaceae
<i>Nasturtium</i>	<i>Calystegia tuguriorum</i>
Violaceae	Solanaceae
<i>Melicytus ramiflorus</i>	<i>Solanum nigrum</i>
Geraniaceae	<i>Physalis peruviana</i>
<i>Geranium molle</i>	Scrophularineae
Rhamneae	<i>Veronica salicifolia</i>
<i>Pomaderris phyllaefolia</i>	Myoporineae
Sapindaceae	<i>Myoporum laetum</i>
<i>Alectryon excelsum</i>	Chenopodiaceae
Leguminosae	<i>Chenopodium pusillum</i>
<i>Ulex europaeus</i>	Polygonaceae
Rosaceae	<i>Muehlenbeckia complexa</i>
<i>Rubus australis</i>	Piperaceae
Myrtaceae	<i>Peperomia Urvilliana</i>
<i>Leptospermum scoparium</i>	<i>Macropiper excelsum</i>
<i>Metrosideros hypericifolia</i>	Liliaceae
Onagrarieae	<i>Cordyline australis</i>
<i>Epilobium Billardierianum</i>	<i>Astelia Solandri</i>
Umbelliferae	<i>Astelia Cunninghami</i>
<i>Daucus brachiatus</i>	<i>Phormium tenax</i>
Cornaceae	Orchidaceae
<i>Griselinia lucida</i>	<i>Thelymitra longifolia</i>
Urticaceae	Filices
<i>Parietaria debilis</i>	<i>Asplenium flabellifolium</i>
Rubiaceae	<i>Asplenium lucidum</i>
<i>Coprosma robusta</i>	<i>Asplenium adiantoides</i>
<i>Galium umbrosum</i>	<i>Polypodium Billardieri</i>
Campanulaceae	<i>Cyclophorus serpens</i>
<i>Wahlenbergia gracilis</i>	<i>Pellaea rotundifolia</i>
Myrsineae	<i>Pellaea falcata</i>
<i>Suttonia australis</i>	<i>Cheilanthes Sieberi</i>
	<i>Pteris aquilina</i>

*Astelia Solandri* is by far the most abundant species, and possesses remarkable structural peculiarities which explain its success. Next in point of numbers comes *Peperomia Urvilliana*, which reaches its greatest luxuriance right in the crevices, sometimes two feet or more from the opening. The ferns *Polypodium Billardieri*, *Pellaea rotundifolia*, and *Asplenium flabellifolium* are also abundant, and grow best as absolute crevice plants, though they are found near and at the surface as well.

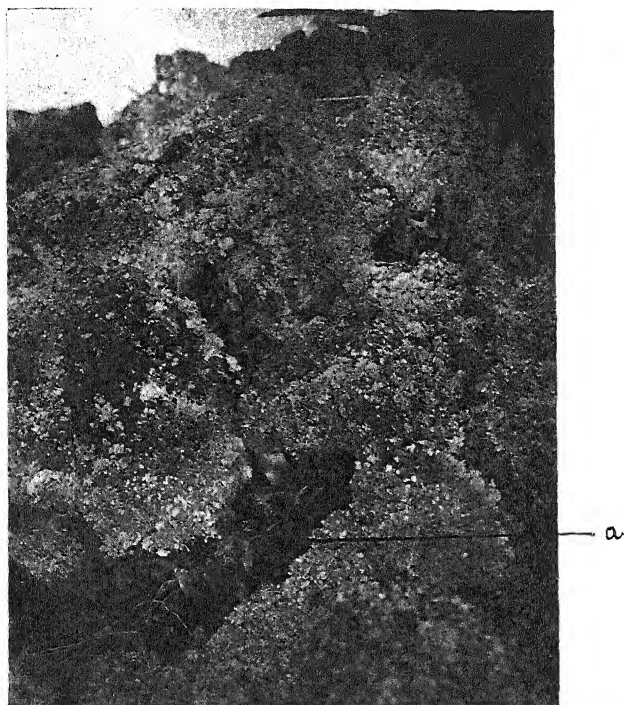


FIG. 1.—*Polypodium Billardieri*.

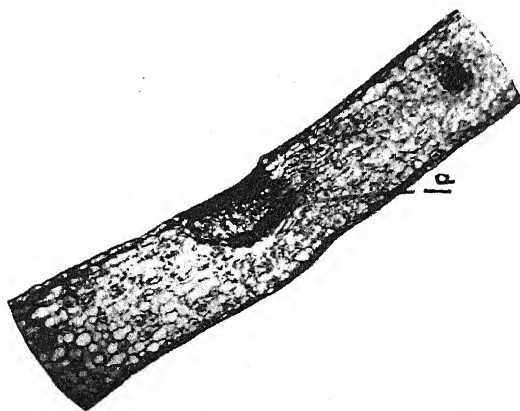


FIG. 2.—*Leaf. T.S.*, showing gland at *a*.

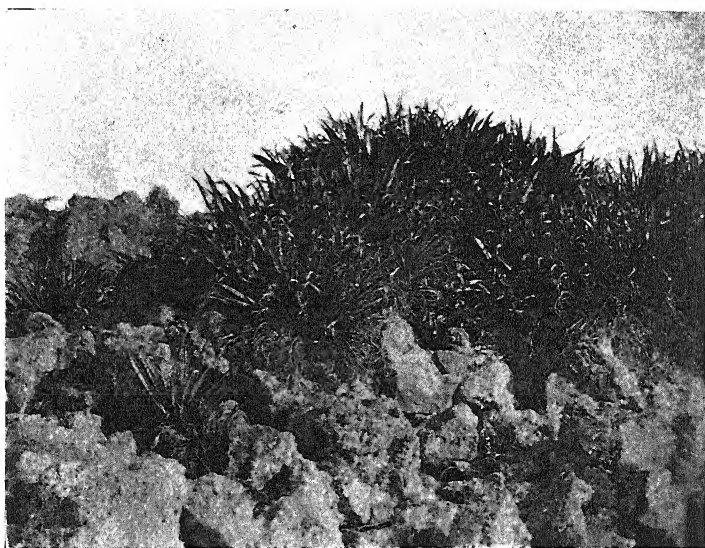


FIG. 3.—*Astelia Solandri*.

## 2. PLANT STRUCTURE.

A. *Asplenium flabellifolium*.

*General description.*—This species of *Asplenium* seems at first sight to be most unsuited for life among rocks. Small stunted plants are found in the shallowest crevices, but it grows best in more sheltered positions and reaches its greatest size in narrow crevices where the light is feeble. Its ability to withstand the conditions of drought which must often prevail is explained after an examination of the roots and rhizome. In plants near the surface the rhizome is extremely short and stout, and from it the fine fibrous roots are given off in dense masses, forming a close mat in which particles of soil are held.

*Leaf.*—There is a thick cuticle beneath which are found the epidermal cells, which are large and often irregular. There is no distinction of palisade and spongy mesophyll, and small intercellular spaces are seen all through. The placenta is a cushion of cells below which is a group of tracheids turned almost at right angles to the vein. The cells of the lower epidermis are smaller and more regular than those of the upper.

The reduction of stomata and the thickening of the cuticle are evidences of xerophytic modification.

B. *Polypodium Billardieri*.

*General description.*—*Polypodium Billardieri* (Fig. 1) occurs as an absolute crevice plant growing most luxuriantly in positions where it obtains as much shade and moisture as possible. It also appears growing on rock surfaces with the roots penetrating into any crevices too small for the whole plant. The creeping rhizome is stout and presents a mottled appearance through the growth of membranous brown scales closely pressed to the green surface. Young branches, leaf bases, and the growing point of the rhizome, are all thickly covered with brown scales. From the somewhat flattened under-surface of the rhizome short fine fibrous roots are given off almost continuously except towards the growing point.

The leaves vary greatly in form, from the simple coriaceous leaf with short stipes found on exposed rock faces, to the large, deeply-lobed fronds with stipes sometimes twelve to eighteen inches long, found in the dampest and most sheltered spots, the size and texture showing a direct dependence on the amount of moisture available. All leaves are alike, however, in one respect. The veins branch and anastomose, forming a network in the meshes of which at the ends of short branch veins are numerous white dots. These are minute scales apparently organic in nature, which cover and protect absorptive glands.

*Structure.—Rhizome.*—The most striking feature about the structure of the rhizome is its adaptation for the storage of water and other reserve materials. A good deal of starch is found in the form

of grains embedded in the protoplasm lining the cell-wall, especially in the cells of the outer cortex and the epidermis. Protein is also found as clusters of transparent granules, particularly in the sieve-tubes of the phloem.

There is a distinct cuticle beneath which are the epidermal cells, lengthened radially. From the epidermis project large multicellular scales, the thickened cell-walls of which are brown in colour.

*Leaf* (Fig. 2).—The epidermis consists of regular brick-shaped cells, longer tangentially than radially. The cuticle is thin, and although there are few stomata on the upper surface they are fairly numerous on the lower, and are of the usual type. There is no distinction of palisade and spongy parenchyma, the mesophyll being made up of rounded cells with scattered chlorophyll grains. About midway between upper and lower epidermis are the vascular bundles, each surrounded by sclerenchyma. The most interesting feature of the leaf is the glands found on the upper surface. These agree very closely in the structural details with those seen in the leaves of one of the Saxifrages growing in positions where the supply of moisture is very small. Each gland is covered by white scales consisting of organic material, probably dead epidermal cells. It is composed of a group of cells forming a roughly hemispherical mass, the surface of which is a little below the surrounding surface of the leaf. Close to the lower part of the gland is the ending of a small vascular bundle. The gland is made up of cells of two kinds—short broad scalariform tracheids, and parenchyma cells with abundant cell contents, yellowish in colour. The epidermal cells are also densely packed with brown and yellow granules which suggests that they may consist of hygroscopic material.

### C. *Pellaea rotundifolia* and *Pellaea falcata*.

*General description*.—The two species of *Pellaea* show very little difference in point of structure, but differ markedly in the situation in which they grow. *Pellaea rotundifolia* is an extremely common form widely distributed, while *Pellaea falcata* is rare, occurring on this lava field only in one spot, though it is very plentiful in that one place. The former grows near the surface in small cracks or among small stones, and the size of the plant varies greatly according to its position. Those plants with the smallest leaves are found growing right at the surface of the rock and the size increases with decreasing illumination until a maximum is reached at a depth of about one foot. *Pellaea falcata* seems to prefer a moister and more sheltered situation, and reaches its maximum size growing among grasses where the mixed forest association has become established, thus forming a striking contrast with the more hardy species which grows in isolation. *Pellaea* plants grow in all the intermediate positions between the bare stones and grass-covered earth, but cannot definitely be assigned to either species, forming an interesting series of transition forms between the two.

The only respects in which *Pellaea falcata* differs are the larger size of the leaves and the separate leaflets and the shape of the latter.

The leaflets of the transition forms gradually increase in size, at the same time becoming longer and narrower and taking up an oblique position with regard to the rachis. In the extreme form described as *Pellaea falcata* the leaf is perhaps eighteen inches long and two inches broad, and the leaflets, which are almost sessile as in all the forms, are curved towards the tip.

*Leaf.*—The structure of the leaf presents several unexpected features, considering that the stem exhibits xerophytic characters. The first unusual feature is the presence of a large number of stomata in the lower epidermis, there being a hundred and forty-seven to the square millimetre. The stomata are of the usual type, having two guard cells which contain chlorophyll grains. They open into large intercellular spaces surrounded by the irregularly-shaped, almost stellate cells of the spongy mesophyll, a structure suggesting a water plant rather than one growing on rock. Where a vascular bundle is cut through, it is seen to consist of a few tracheids with parenchyma cells and phloem towards the lower surface. The palisade tissue is distinguished from the spongy mesophyll by having smaller intercellular spaces and being composed of cells more regular in shape and more densely packed with chlorophyll. Most of the cells are broader than they are long, and are somewhat rounded. The cells of the epidermis are fairly regular and the cuticle is thin.

#### D. *Astelia Solandri*.

*General description.*—This *Astelia* forms a most characteristic feature of the vegetation of the lava fields, many parts of which it occupies almost exclusively. *Astelia Solandri* (Fig. 3) is a perennial, and indications point to its living for many years. The plant forms a tuft emerging from the crevice. The living leaves extend to about four or five inches back from the growing point and are arranged in a close spiral, the youngest ones being folded together to protect the growing point. The leaves are ensiform, about thirty inches long and an inch and a-half wide, and expand into bases about four inches wide and almost black in colour. Dense masses of silky white hairs clothe the leaf bases where they join the stem. Their function would seem to be to help to check the evaporation of the water for which the leaf bases form a reservoir. Even in dry weather there is usually a considerable quantity of water to be found. Below the living leaves are the dry ones of the preceding years, the damp bases of which are in various stages of decomposition. An obvious adaptation to life as a crevice plant which is entirely lacking in epiphytic members of the species is the production of a woody stem in which secondary thickening is developed. The living part of the stem is perhaps eight inches long, but the decaying tissues retain their form for some distance below. The plant does not project far above the surface of the rock, the decaying stem and leaves being apparently thrust deeper and deeper into the crevice. In the case of one specimen from a particularly deep crevice the length from the growing tip of the stem to the end was very nearly two feet. For about half this distance the woody stem could plainly be seen while the rest consisted of a mass

of humus bound together by the roots and leaf-fibres, and still preserving the original shape. This example shows the important part played by these *Astelias* in the formation of soil and the gradual filling up of the crevices. As would be expected from the mode of growth of the stem, the roots are adventitious, a fresh root system being produced each year. In plants examined in the spring root tips were forcing their way through the leaf bases only an inch and a-half, or even less, from the growing point of the stem. The roots turn in all directions, some entering the cracks in the rock and forming a most efficient anchoring system, others hanging freely in the air, and a third set turning upwards and applying themselves closely to the leaf bases to absorb the water and dissolved salts held there.

*Structure.—Root* (Fig. 4).—The cortex readily breaks away from the vascular cylinder at the thick-walled endodermis, so that the inner and outer parts of the root frequently appear separately in section.

The centre of the vascular cylinder consists of small rounded cells, surrounding which is a wide region of much thickened cells with lumina which become smaller towards the pericycle. At the outer edge of the ground tissue is a ring of numerous vascular bundles, consisting of xylem groups alternating with phloem. The xylem consists of large scalariform vessels with smaller celled protoxylem towards the outside. The protoxylem is made up of spiral tracheids. Between the xylem groups are the small thin-walled cells packed closely together, which form the phloem group. The whole vascular cylinder is bounded by the pericycle consisting of small square cells with extremely thick walls, which in longitudinal section are seen to be pitted. Outside the pericycle is the endodermis, made up of larger cells, also with thick walls.

The outer cortex may be divided into two regions. In the interior are rounded living cells, many of which have dark brown cell contents, probably tannin compounds, while outside these is a zone of dead cells, most of which have thin walls though a few are very much thickened and show pits on their walls. The function of these dead cells, like that of the velamen of the epiphytic orchids, is to absorb and hold any moisture with which they come in contact. Experiment shows that they absorb the moisture with great rapidity. Towards the outside of the root is a layer of large rectangular cells and outside these are two or three rows of extremely irregular cells, many of which are prolonged into root hairs. These persist even in the older parts of the root and help to check the evaporation of any moisture absorbed. Twisted around many of the hairs are very fine fungal hyphae, which do not, however, penetrate the cells of the root.

*Stem*.—An older stem shows many differences from a younger, the chief being the appearance of secondary meristem (Fig. 5) which increases in amount with increasing distance from the growing point. Unlike the secondary meristem of *Cordyline*, which produces both ground tissue and more vascular bundles, that of *Astelia Solandri* produces only ground tissue. This is readily explainable, since, as the functional part of the stem is only a few inches long, and a new root system is produced each year near the apex, extra conducting tissue

*Astelia Solandri*.

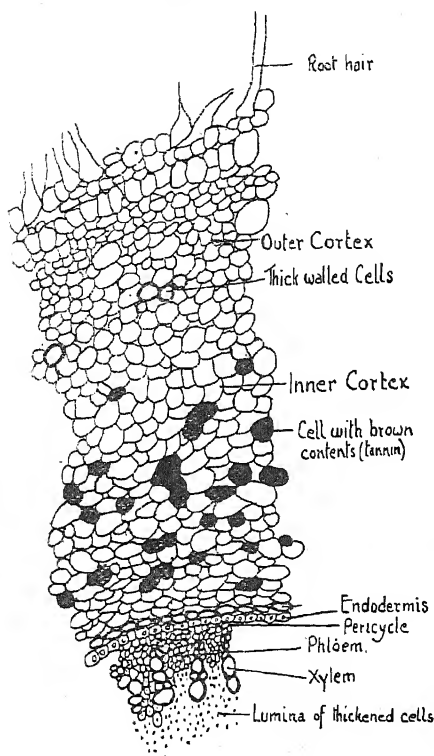


FIG. 4

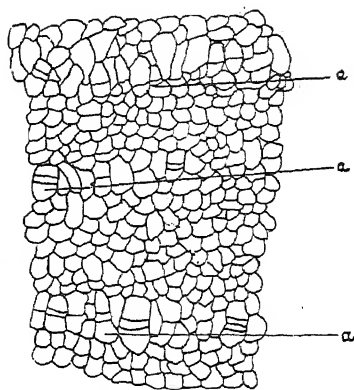


FIG. 5

*Astelia Solandri*

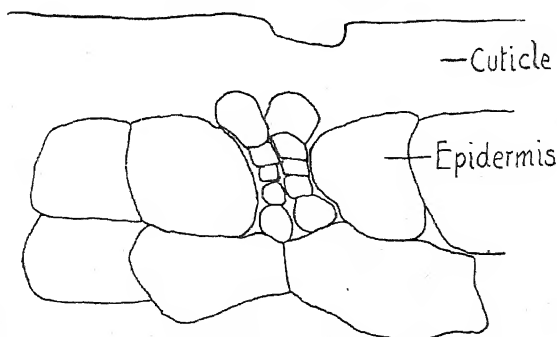


FIG. 6

FIG. 4.—Root. T.S. ( $\times 80$ ).

FIG. 5.—Cortex of *Astelia Solandri* stem, showing meristem at a.

Drawn from a photomicrograph.

FIG. 6.—Water-absorbing Organ of Leaf. T.S. ( $\times 400$ ).

is not needed. The meristematic layer first appears just inside the epidermis as a row of large irregular cells which divide either tangentially or radially. They do not remain active for long, but before division ceases they cut off a new meristem on the outside. This new cambium produces cortical cells on its inner side so that it is soon separated from that first formed by several layers of cells, some of which have thickened walls in which are pits. When the second cambium is exhausted it gives rise to a third layer which divides just as the other two did, and may in its turn produce a fourth layer, and this a fifth. The layers produced later consist of smaller and more regular cells, and so approach more nearly to the typical cambium than do those formed first. The cambium does not form complete rings, but is frequently interrupted. Much of the parenchyma of the cortex, meanwhile, has become sclerized and the pericycle has greatly changed. Near the growing point it is made up of narrow, thin-walled cells, but by the time the stem has become woody and secondary thickening has begun, it consists of wide, very thick-walled cells, which in longitudinal section are seen to be pitted.

*Leaf.*—At the base the *Astelia* leaf is colourless, and the cells show very little differentiation. Much starch is stored in this region. Further away from the point of attachment to the stem the leaf broadens out into the dark-coloured portion mentioned above. The colour here is due to the extremely thick cuticle which is composed of scales of wax closely pressed together. When seen separately they are a golden yellow, but in the mass they appear black. Thin places or even pits are left in the cuticle, showing, in a section cut parallel to the surface, as pairs of rounded, light-coloured spaces. These correspond to the position of specialized epidermal cells, the numbers of which in the leaf bases where water is held are so much greater than in other parts of the leaf that the conclusion is reached that they are absorbing organs.

A transverse section of the blade of the leaf shows that under the thick cuticle there is an epidermis of two layers of small rounded, regular cells, those of the inner layer being slightly larger than the outer ones. At intervals are deeply sunken stomata of the usual type with two guard cells containing chlorophyll grains. Each stoma opens into an inter-cellular space. Between the stomata are the water-absorbing structures which consist of two rows of four or five cells, those nearest the centre and those on the outside being larger and rounded, while those between are smaller and flattened and have brownish cell contents (Fig. 6). Below the epidermis is the mesophyll in which there is no distinction of palisade and spongy mesophyll, though the cells towards the upper surface are smaller and contain more chlorophyll. The lower epidermis resembles the upper except that the cells are larger and there are more hydathodes. Bridges of sclerenchyma are found embedding the larger veins, and groups of sclerenchyma occur below the smaller ones, thus supplying the mechanical support necessary for a large leaf. Mucilage ducts occur towards the lower surface opposite the smaller veins and on each side of the sclerenchyma embedding the larger ones. The ducts are formed by the breaking up of cells and secrete large quantities of

colourless mucilage which exudes rapidly from cut surfaces and sets like a jelly in the air.

### E. *Peperomia Urvilliana*.

*General description.*—*Peperomia Urvilliana* grows as an epiphyte and also in all parts of the lava field from the surface to the deepest crevices. It grows more luxuriantly in the deeper crevices where it gets more shelter. Here the plants form large masses with long branching stems and leaves larger and of a paler green than those of plants nearer the surface. The bulk of the stem is made up of large-celled water-storage tissue, in which are scattered chlorophyll granules. A peculiar feature of the vascular system, common to the order Piperaceae, is that the bundles are arranged in an outer and an inner series. Each is bounded by pericycle and endodermis of small regular cells.

*Leaf.*—The upper epidermis has a thick cuticle and consists of small cells, which are barrel-shaped in transverse section. Under this are four or five layers of large water-storage cells devoid of chlorophyll, among which are oil cells. There is a single layer of palisade parenchyma, long narrow cells closely packed with chlorophyll. Two layers of rounded cells also packed with chlorophyll are seen below the palisade cells and a broad band of irregularly-shaped parenchyma containing scattered chlorophyll grains, stretches to the lower epidermis. This resembles the upper epidermis except for the presence of hydathodes, funnel-shaped cells beneath which are mucilage cells. Stomata are seen in both upper and lower epidermis, and are of the usual type. Leaves from the crevices differ from surface leaves in having the chlorophyll less strongly developed and in there being more oil-cells among the water-storage cells. According to Haberlandt these are probably of use in focussing light on the chlorophyll cells below.

## The Vitamin "A" (Anti-Ophthalmic) Content of Butter and Spinach.

By LILLIAN BOYNTON STORMS, Ph.D., Home Science Department,  
Otago University.

[Read before the Otago Institute, 14th September, 1926; received by Editor,  
31st December, 1926; issued separately,  
8th November, 1927.]

IN 1913, McCollum and Davis (1) and Osborne and Mendal (2,3) showed that the presence of vitamin A or fat soluble vitamin was necessary in the diet of albino rats in order to secure normal growth, for the prevention of eye disease and other infections, and for satisfactory reproduction. Without vitamin A normal growth was retarded after 60 to 70 days of age, many rats developed an ophthalmia, and unless the deficiency was supplied the weight declined and death resulted at about  $3\frac{1}{2}$  months of age.

In 1919 E. Mellanby in work on puppies (4) showed that a fat soluble substance seemed necessary for the proper calcification of the bones and called it the "anti-rachitic factor," because of its value in the prevention and cure of rickets. At that time it was thought a single factor, fat soluble vitamin A, was responsible for all the results when rats suffered from a lack of the fat soluble substances.

Since 1922 the work of Powers, Park and Simmonds (5), McCollum and his associates (6), and Steenbock and associates (7), has shown the existence of at least two substances involved in the fat soluble fraction, one the anti-ophthalmic and the other, the anti-rachitic factor. This is shown by the destruction of the anti-ophthalmic factor in cod liver oil by aeration, (i.e. oxidation) where as the oil after this treatment is still potent in its effect in the cure of rickets, and the securing of a normal deposition of calcium in the bones and of promoting some growth.

As a consequence most of the work hitherto done on vitamin A or fat soluble vitamin will now need to be repeated, or at least reinterpreted in the light of the more recent work, for we must be able to distinguish between the effects resulting from the presence or absence of these two very different substances, the anti-ophthalmic (vitamin A) and the anti-rachitic (vitamin D).

Steenbock, Nelson and Black (8) have revised the technic for determination of vitamin A, so as to differentiate between vitamin A and vitamin D. In order to determine vitamin A, it is necessary to supply vitamin D by the use of aerated cod liver oil or direct radiation with ultra violet rays. By means of a basal ration free from both vitamins, addition of aerated cod liver oil or direct radiation supplies vitamin D only, and foods can then be tested for their content of vitamin A. After the vitamin A content is found we can test for content of vitamin D.

We have tested out our basal ration which lacks both vitamins A and D to be certain of its deficiency, we have then added aerated cod liver oil to the basal ration and determined the effects resulting upon this addition of vitamin D. With this ration (basal plus aerated cod liver oil) we have then tested butter and spinach for their content of vitamin A. By the results we can distinguish between the effects produced by the two fat soluble substances in question.

#### EXPERIMENTAL PROCEDURE.

In these experiments albino rats were used, whose parents were of the same stock and had all been raised on our standard colony diet, with the exceptions noted in the first experiment. This ensured an identical previous pedigree and nutritional history. They were separated from their mothers at 28 or 29 days of age and put on the experimental basal ration. They were weighed once a week and the tables and charts give the average weekly weights. It has been repeatedly determined, that animals of the same age placed on a vitamin -A-free diet, are able to survive the deprivation for varying lengths of time, depending upon the extent to which the previous diet has allowed opportunity for storage of this factor (9). Hence our animals had uniform advantages from the previous diet. Another important condition governing the length of the survival period, is the age of the experimental animals (10). Our animals have been taken at a uniform age, and weighing from 32 to 52 gms. The controls on the basal diet were chosen so as to represent the different litters used in the experiments. No average is taken using only the rats from one litter, for occasionally a whole litter will show peculiar susceptibility or resistance to a lack of vitamin A. The rats of any one litter were therefor put on different amounts of the food being tested.

Large numbers of rats would smooth out the curves, but the general relationships and tendencies from the different diets would probably remain the same, for the deviation of individual rats from the averages is not unreasonable, and the results from all of the rats on any one diet are near enough to the average, and show the same tendencies to justify the conclusions drawn.

The basal diet, laboratory diet A-2, is the same as that used by Sherman at Columbia University (11) and almost identical with that used by Steenbock at the University of Wisconsin (12) in carefully conducted quantitative work on vitamin A deficient diets. We have used marmite as a source of vitamin B as used by the English investigators, instead of yeast as used by the Americans.

Diet A-2; corn starch 78%, extracted casein 12%, NaCl 1%, salt mixture 4%, marmite 5%.

Steenbock uses dextrinized starch and 2% agar in his basal diet instead of corn starch. The casein was extracted three times with alcohol under a reflux condenser, the boiling continued for one hour at each extraction and the casein filtered by suction while hot. This procedure has been shown by Sherman and Munsell (17), and

also by the results obtained in this laboratory, to be adequate for destruction of vitamin A. The salt mixture was Osborne and Mendel's salt mixture made up to approximate the composition of the ash of milk (13).

The alcoholic extraction of the casein probably removes the anti-rachitic vitamin as well as vitamin A, as shown by the rapid cessation of growth when no additional source of vitamin was added to the diet, and also by the subsequent considerable stimulus to growth, when aerated cod liver oil supplying vitamin D was added. Complete removal of vitamin A is evident from the behaviour of the control rats.

The oxidation of the cod liver oil was conducted as follows; in a boiling water bath a stream of warm air was bubbled through the oil for twenty hours (7). The incidence of ophthalmia when this oxidized cod liver oil was added to the basal diet with the autopsy findings, shows the oxidation and destruction of vitamin A must have been complete; and using this oil at a 3% level in the diet supplied sufficient vitamin D (without vitamin A) to stimulate growth. Using the same stock of animals the addition of sufficient butter, dried spinach, or lettuce to this basal diet plus 3% oxidized cod liver, we have obtained normal, or better than normal growth over a period of time longer than used in these experiments. Hence the basal diet is not only free from vitamins A and D, but when supplemented with these substances is adequate for good growth, so is lacking only in the factor being investigated.

The experimental diet and distilled water were furnished *ad libitum* through out the experiments.

It is necessary that all other factors except the one being investigated be supplied and all influencing conditions controlled. Rats are now standard reagents, that is, we know their reactions as definitely as we know chemical reactions. The following additional precautions were taken. The temperature of the room was kept at between 13 and 19° C. since it is found that the weights of both normal and experimental rats will be lowered if the temperature of the room drops below about 13° or varies within wider limits. Rats on control or basal diets were kept in separate cages from those receiving additions to the diets because such rats will, we have found, consume sufficient excreta of the other rats to supply an appreciable amount of the missing factor. Also the cages have wire screen bottoms, and no bedding has been used since bedding may collect excreta and also bacteria, a possible source of additional vitamins. The wire screen bottoms of the cages were changed and washed each day. No direct sunlight ever touched the cages or rats, though the rat room gets some early morning sun. The literature on these matters furnishes experimental evidence of the value of these precautions (11, 12).

Finally, that death was caused by a lack of vitamin A or D or both was confirmed by careful daily observation of the experimental animals, and the autopsy examination for such signs of deficiency of vitamins A and D as the characteristic abscesses in the glands at the

base of the tongue, the frequency of infections of the sinuses and the middle ear and bronchial tubes, abnormal reproductive organs, abnormal intestines and beading of the ribs, or enlarged costochondral junctions. The incidence of ophthalmia, respiratory troubles, the condition of the skin and hair, and the humped condition always occurring before death in the control animals were all noted, and left no doubt that the cause of death in the control animals was a lack of the fat soluble substances. Furthermore, we were able to distinguish between the effects attributable to each vitamin.

Ophthalmia does not evidence itself in all rats supposedly on vitamin A-free diets. Osborne and Mendel (13) found 60% incidence in a group of 493 rats, Stammers (14) had 88% occurrence, Wagner (15) 60 to 70%, Sherman and Munsell (17) 85%.

A week's supply of butter or spinach was weighed up at one time and fed by hand in three allotments on alternate dates.

#### EXPERIMENTS ON BUTTER AS A SOURCE OF VITAMIN A.

Rats used in the first series of experiments were of our new colony, and inferior in weight to those used later, but the growth curves show the same general tendencies and are included for comparison. By using a good stock diet we have since improved our colony animals.

TABLE 1.

#### ADDITIONS OF BUTTER TO THE BASAL DIET.

Average weekly weights from 35 days after weaning.

Butter gms. daily	No. rats	Cessation of growth in days	Survival in days	WEEKS								
				5	6	7	8	9	10	11	12	
0	4	—	75	63	67	67	70	68	67	61	54	D
.025	3	35	—	73	75	74	73	71	71	71	66	K
.05	7	35	—	61	63	67	68	68	69	72	74	K
.10	6	36	—	58	62	64	65	67	67	71	69	K
.20	3	37	—	59	63	64	71	74	73	73	73	K

Different amounts of butter added after active growth had ceased, i.e. after about 35 days on the basal diet.

The effect of additions of butter to the basal diet are shown in Table 1 and Chart 1. Except for those included in Chart 3 the weights and growth curves are not given for the preliminary period on the basal diet (from weaning at 28 days of age until 35 days later when active growth had ceased). The charts show the average weights of the rats on any one diet after the preliminary "running down" period and show the effects produced by the additions of butter.

Apparently with the first rats of somewhat inferior quality .025 gm. butter daily added after the preliminary period on the basal

diet was inadequate to supplement the basal diet, since the curve shows no growth, and but a slightly longer survival than the control rats. .05 gm. butter daily gave a slow but evident impetus to growth. The lack of the anti-rachitic vitamin was not supplied by the larger amounts of butter (.1 and .2 gm. daily), as shown by the very slightly better growth made on those amounts.

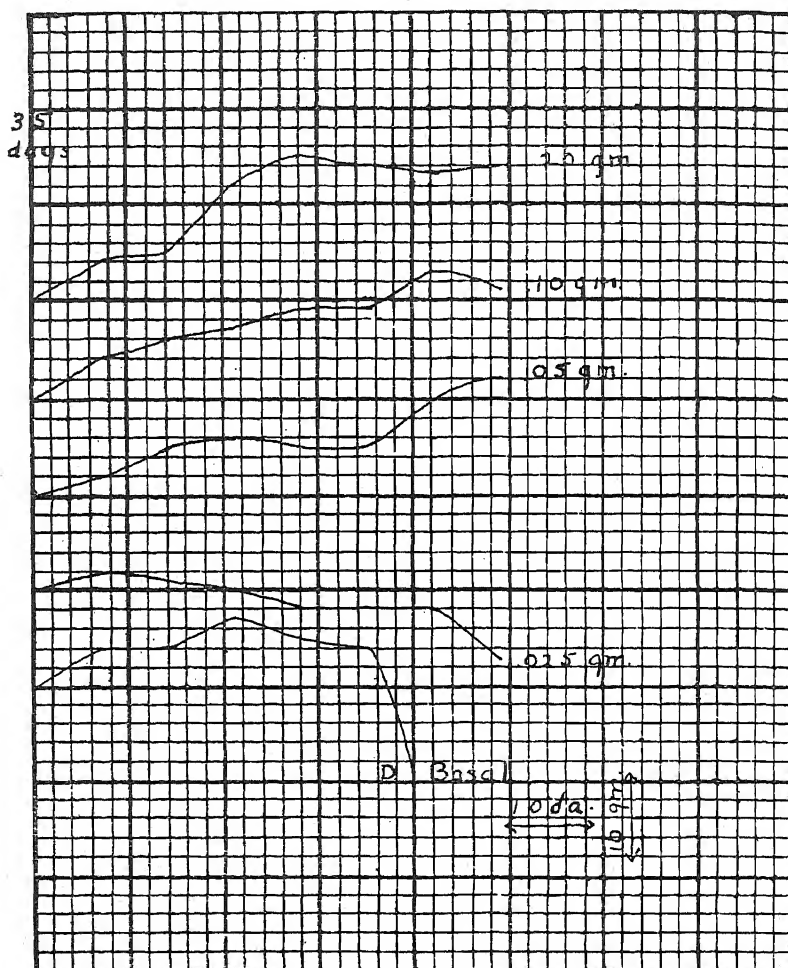


CHART 1.

Gains in weight after additions of Butter, added when growth had ceased, at about 35 days after weaning.

This experiment shows butter to the extent of .2 gm. daily to be inadequate in its supply of anti-rachitic vitamin to induce normal growth when added to a basal diet lacking both vitamins A and D. Drummond and Coward (9a) found .2 gm. butter daily, gave slow but steady growth to a non-growing rat. Sherman and Munsell (23)

found .025 gm. butter daily added to this same basal diet adequate to induce a gain of 25 gms. in weight in eight weeks. In the case of no single rat did we get any gain on this amount; they all lost from 2 to 13 gms. weight in seven weeks. Macroscopic examination and autopsy findings, show an absence of eye trouble and pus at the base of the tongue in all rats where butter was added, so the supply of vitamin A was adequate to prevent infections when added in as small amounts as .025 gm. per day.

The butter purchased by Sherman and Munsell on the New York City market, and that used by Drummond and Coward secured in London appear to have contained more vitamin D than did our supply. The cows in England and in New York State are kept in stalls and fed on dry food for a part of the year, whereas the cows in this vicinity are left out doors the entire year, and we expected more anti-rachitic factor to be present in the butter on our markets. This point will need to be investigated further by the use of butter of more than one brand secured at different seasons of the year and used with a better stock of animals.

The four control rats with no butter all developed ophthalmia, the average occurrence being at 54 days after weaning (82 days of age), all showed pus at the base of the tongue and very little or no fat in the abdominal cavity. Practically all of the twenty-two rats used in this experiment showed some evidence of haemorrhagic ribs and enlarged costochondral junctions, which were not found in rats supplied with oxidized cod liver oil (supplying vitamin D), although the condition of those receiving butter appeared superior to that of the controls.

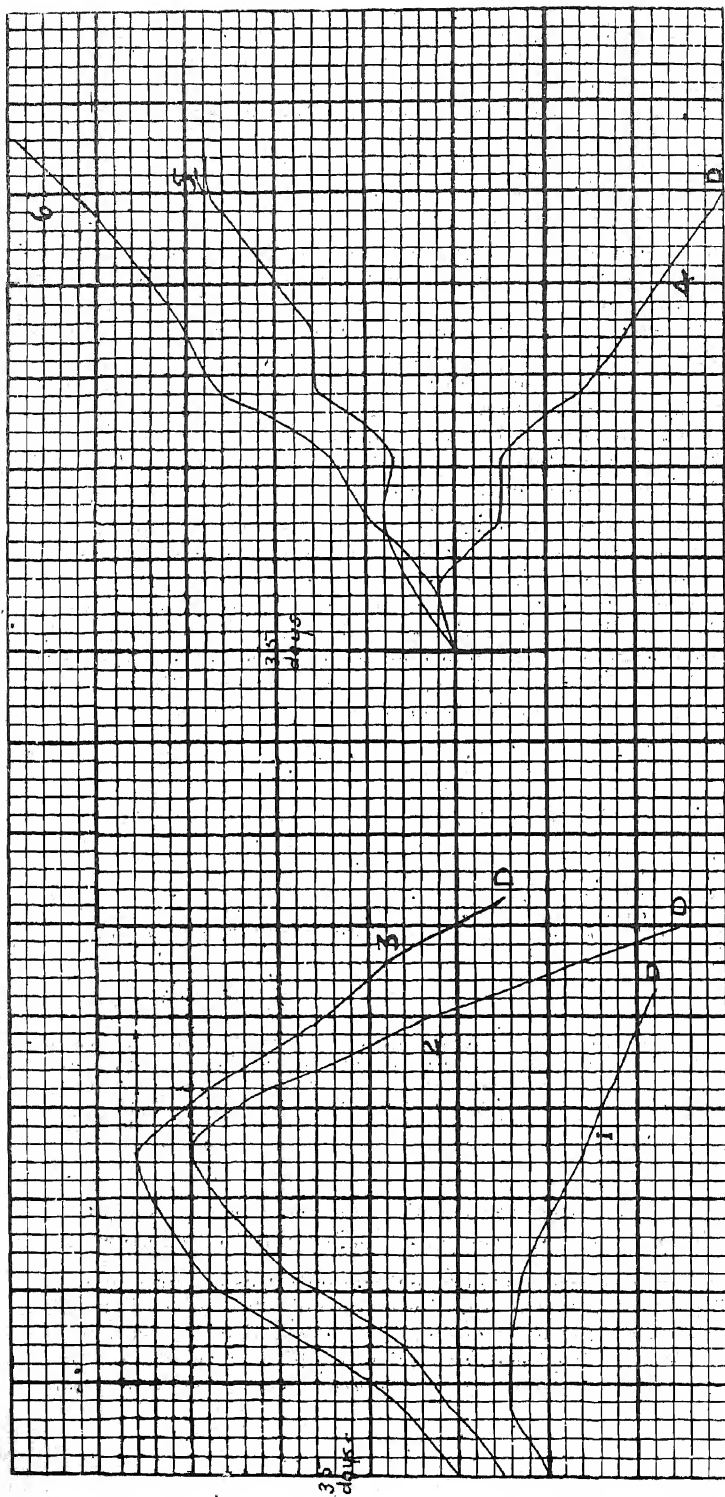
TABLE 2.

ADDITIONS OF COD LIVER OIL AND BUTTER TO THE BASAL DIET.

Weaning or days after weaning when cod liver oil and butter were added		Gm. Butter daily	Cessation of growth in days	Survival in days	No. rats	WEEKS Average weekly weights in gms.												
3% c.l.o.	Butter					5	6	7	8	9	10	11	12	13				
42	—	—	42	95	2	80	86	91	103	110	115	106	89	66	D			
W	—	—	—	88	4	92	96	96	95	92	88	85	75	D				
44	44	.025	44	92	4	93	99	109	121	126	129	121	109	88	D			
W	46	.05	46	85	3	106	108	101	101	92	87	84	76	D				
W	40	.10	40	—	5	89	94	97	96	104	105	110	116	117	K			
W	W	.10	—	—	3	88	90	97	102	114	118	123	130	137	K			

Additions of 3% oxidized cod liver oil and varying amounts of butter to the basal diet at weaning and after cessation of growth.

In the second series of experiments on butter as a source of vitamin A (Table 2, Chart 2) oxidized cod liver oil, 3% of the diet, was added to the basal diet at weaning, death occurred in an average of 88 days. When oxidized cod liver oil was added at the time active growth ceased, the resulting stimulus to growth was pronounced, but

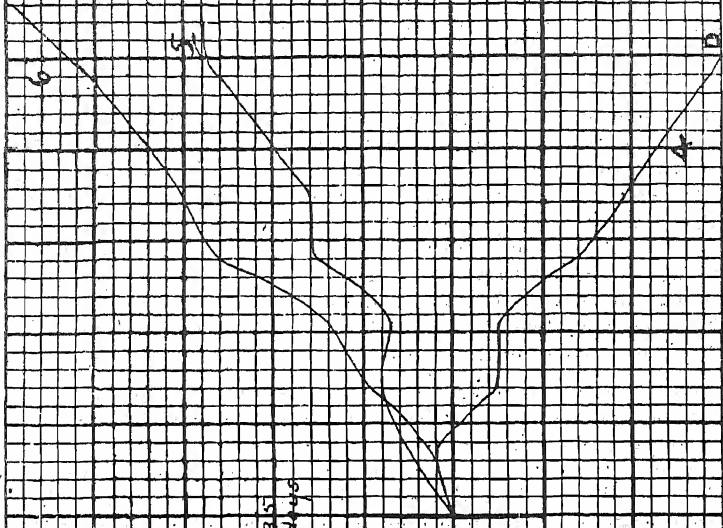


1. Plus cod liver oil from weaning.
2. Plus cod liver oil after cessation of growth.
3. Plus cod liver oil and .025 gm. butter daily after cessation of growth.

CHART 2.

Plus cod liver oil at weaning—

4. and .05 gm. butter daily after cessation growth.
5. and .10 gm. butter daily after cessation growth.
6. and .10 gm. butter daily from weaning.



disaster resulted in 95 days. When oxidized cod liver oil, 3% of the diet, and .025 gm. butter daily were both added when growth had ceased, death resulted in 92 days after weaning, and the curve is almost identical to that when cod liver oil, but no butter was added. The stimulus to growth was evidence of the presence of vitamin D in the oil. The stores of vitamin A were apparently exhausted and .025-gm. butter daily did not supplement for the deficiency, a support to the failure obtained in the first experiment when .025 gm. butter without cod liver oil gave no better result than the basal diet alone.

The second set of curves in Chart 2, shows the changes in weight after 35 days from weaning when 3% oxidized cod liver oil was added at weaning, i.e., a basal diet including the antirachitic factor, and varying amounts of butter added when active growth had ceased. Even with the addition of .1 gm. butter daily, the curve is considerably below a normal curve.

It is of interest to compare the effect of addition of .05 gm. butter daily after growth had ceased when no cod liver oil was added, with the result when cod liver oil had been added at weaning. The increased growth due to the active principle furnished in the cod liver oil, vitamin D, apparently means a greater requirement for vitamin A on the part of the more rapidly-growing organism. In Chart 1 .05 gm. butter was added to diets of rats of an average weight of 61 gms. and in Chart 2 the same amount of butter was added for rats of an average of 106 gms. weight. This amount of butter was inadequate after the growth-stimulation caused by the vitamin D in the oil.

The use of .1 gm. butter daily from weaning gives a nearer approach to the normal curve bearing out the evidence of Osborne and Mendel (18) that in their experience smaller amounts of vitamin containing foods are required, when such foods are supplied from the start as a preventative measure than when given as a supplement after severe nutritive decline has set in. This gives experimental evidence of the superior value of preventative dietary measures over curative treatment.

Another comparison of these data is given in Chart 3, in which the weight curves from weaning of rats on the basal diet alone are compared with the impetus to growth given by additions after growth had practically ceased, on .025 gm. butter daily (curve 2), 3% oxidized cod liver oil (curve 3), and the same amounts of butter and oil added together (curve 4). The rats used when the cod liver oil was added (curves 3 and 4) were of later stock and superior to those used at first (curves 1 and 2); however, death resulted in about the same length of time. Evidently death was caused by a lack of vitamin A, and the addition of oxidized cod liver oil supplying factor D, and even of small amounts of butter, did not adequately supply the missing essential substance, although better growth resulted for a time. The rats included in curves 3 and 4 from better stock, were of larger weights at weaning, and presumably would have better stores of both vitamin A and D, from the previous diet of the parents and what they ate of the stock diet before weaning.

This merely emphasizes the inevitable failure resulting from a lack of vitamin A.

#### EXPERIMENTS ON SPINACH AS A SOURCE OF VITAMIN A.

The basal diet already described was used, including 2% oxidized cod liver oil to supply vitamin D. Varying amounts of dried spinach were furnished either at weaning as a protective measure or

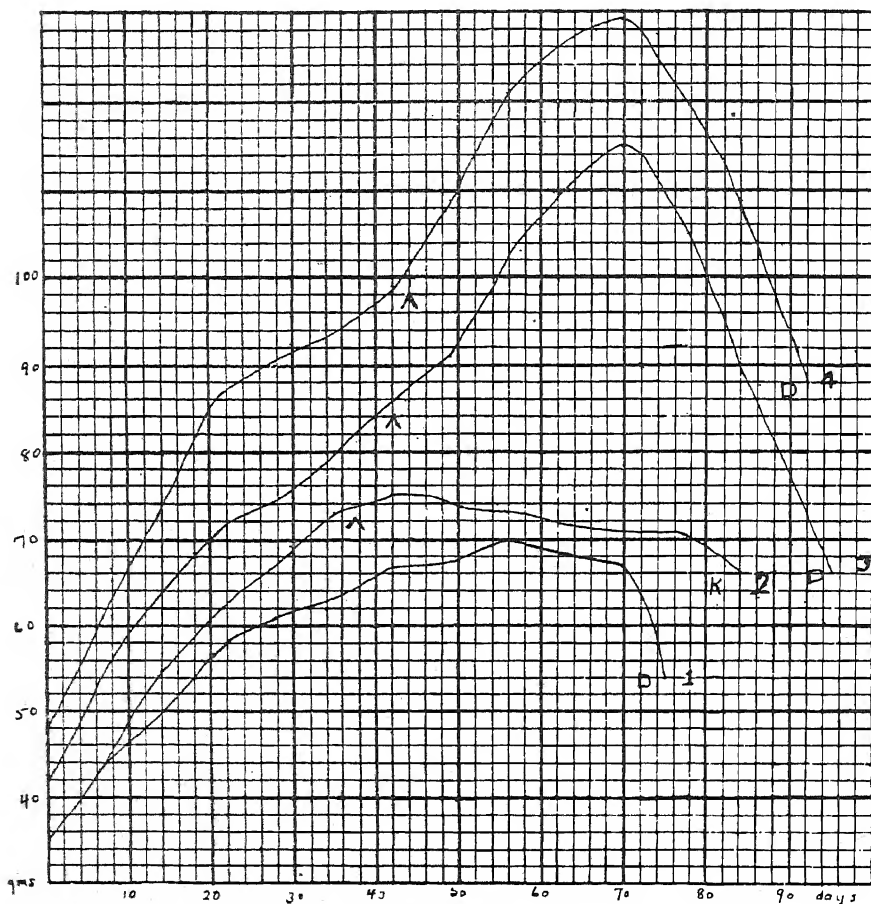


CHART 3.

Growth from weaning, showing the effects of additions to the Basal Diet, of cod liver oil and butter after cessation of growth.

1. Basal Diet only.
2. Plus .025 gm. butter at A.
3. Plus cod liver oil at A.
4. Plus cod liver oil and .025 gm butter at A.

as a curative supplement after active growth had ceased. The spinach was dried in a large gas oven (gas stove) at a very low temperature with the door wide open, so there was no strong current of

air going through the oven. It was stored in an air-tight tin, taking care throughout that oxidation of vitamin A was avoided as much as possible.

TABLE 3.

ADDITIONS OF DRIED SPINACH TO THE BASAL DIET PLUS COD  
LIVER OIL.

Changes in weight when spinach added after cessation of growth.

Spinach gms. weekly	No. rats	Cessation of growth in days	Survival in days	WEEKS Average weekly weights in gms.											
				5	6	7	8	9	10	11	12	13	14		
0	4	—	88	92	96	96	95	92	88	85	75	68	D		
.015	4	43	—	88	93	95	99	99	105	105	105	109	109		
.025	3	43	—	91	91	98	103	105	108	111	113	119	120		
.05	4	40	—	84	85	91	98	101	107	113	115	121	121		
.10	3	37	—	85	85	95	105	107	112	116	120	125	128		
.20	2	36	—	84	92	99	110	114	126	132	139	145	147		

Additions of varying amounts of dried spinach to the Basal Diet supplemented by 2% oxidized cod liver oil. The spinach was added after cessation of active growth. The weights given are the averages after 35 days on the Basal Diet with cod liver oil.

In Table 3 and Chart 4 the weights are not given for the preliminary period from weaning to 35 days later. Active growth ceased in from 36 to 43 days on the basal diet supplemented with the oxidized cod liver oil. The weights are given from 35 days on, so that effects due to additions of spinach are evident. .015 gm. dried spinach per week or .0021 gm. daily, was sufficient to prevent any evidence of ophthalmia, and in no case was pus found under the tongue. Evidently adequate vitamin A, was furnished by this small amount of spinach to protect against infections, but not enough for much more than maintenance of weight. As other investigators have found in similar work, there is a wide middle ground between maintenance and good growth.

Sherman and Munsell (17) found in feeding fresh spinach, that .017-.018 gm. fed daily (.119 to .126 gm. fresh per week) gave a gain of about 25 gms. in weight in eight weeks. We secured an equal gain on dried spinach with .025 gm. a week or the equivalent of .312 gm., fresh spinach per week. The experiments are not comparable because they were relying on the spinach to furnish vitamin D, which means that furnishing vitamin D, we expected to secure the same growth on smaller quantities of spinach. We have in all probability lost some of the original content of vitamin A by the drying process, but our spinach could not have had the original content of vitamin A, which was contained by that used by Sherman and Munsell, obtained on the New York City market.

McClendon and Shuck fed dried spinach as .1% of the food eaten, and secured a distinct retardation of ophthalmia. Rats of

this age and weight, eat about 45 gms. of food per week, which means .045 gm. dried spinach per week.

Further experiments are in progress using spinach from weaning instead of after a nutritive decline has set in; and while not sufficiently complete for results, the indications are that as with butter, a slightly better uniform growth is secured on corresponding amounts

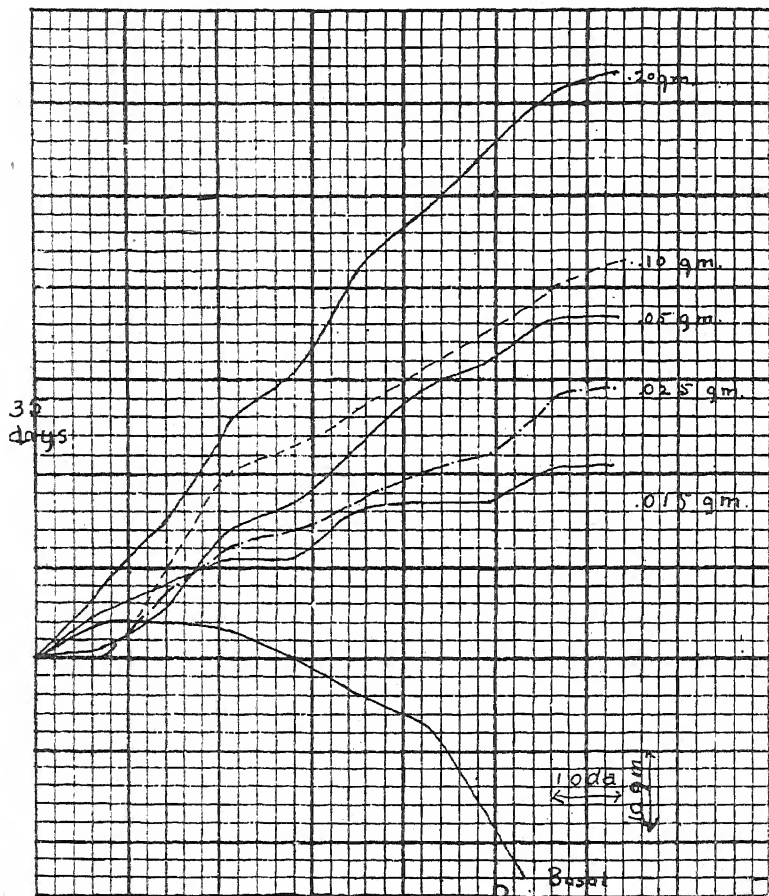


CHART 4.  
Changes in weight after 35 days on Basal Diet and Cod Liver Oil upon additions of dried spinach. Specified amounts fed weekly.

of spinach, and the weights of the rats at the end of 14 weeks from weaning, are equal to or better than those of this experiment.

#### PRACTICAL AND SOCIAL SIGNIFICANCE.

Both experiments with additions of butter and of spinach, show that very small amounts protect against infections, but very much

larger amounts are necessary before normal growth can be obtained. Furthermore, what we call normal growth is not necessarily optimum. There is a wide field where increasing quantities of vitamin A, induce increasingly more favourable results, but for optimum physical well-being much more than a minimum is necessary. It is recognized, that rats grow at a much faster rate than human beings; and as Mendel has said, we do not know the factor to enable us to transfer findings on animals, such as the rat to human beings; but we do know from the dietary experiment unwittingly conducted during the war, that much human experience can now be interpreted in the light of animal experimentation. We now know that in human beings it is quite possible that general physical debility, lack of stamina and vitality, and quite possibly size of stature could be greatly improved by an optimum instead of a minimum supply of essentials such as the vitamins have proved themselves to be.

Another practical aspect is evident in the better condition of rats whose dietary included the factor vitamin A from weaning over those who were allowed to cease active growth before being supplied the supplement of vitamin A. The general social and economic importance of prevention over cure is self evident.

#### SUMMARY.

This work was undertaken to ascertain the vitamin A content of butter and spinach obtainable locally. Before any quantitative work on food content of vitamin D can be carried out it has been necessary to determine vitamin A and vitamin D as separate entities, the results upon deprivation of each, and find a source of vitamin A which can be supplied with the basal diet without vitamin D. Knowing now the growth to be expected when vitamin D is furnished in adequate amount and vitamin A is supplied by .1 gm. of butter daily and .025 gm. spinach, we are starting on the vitamin D content of butter and spinach. Last year we did a few calcium determinations on the animals used, but this year, because of inadequate laboratory space and time, no such work has been possible. However we have found that our normal animals on our stock diet have the same amount of calcium in their bodies as do those of other laboratories as given in the literature. By feeding low or free from vitamin D rations the calcium content will need to be determined also.

The thanks of the author are due to Miss E. N. Todhunter for technical aid.

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## Calcium Content of some New Zealand Foods.

By LILLIAN BOYNTON STORMS, Ph.D., Home Science Department,  
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31st December, 1926; issued separately,  
8th November, 1927.]

It is possible that the notoriously bad condition of the teeth in the Dominion may be due in part to a lack of necessary teeth-building materials, of which calcium, phosphorus, and vitamin D are the most conspicuous. A condition of goitre is prevalent, and it is now known that a lack of iodine in the food is a primary factor in its cause, and that prophylactic treatment with iodine salts is efficacious. A disease known as "bush sickness" in the North Island, although affecting apparently only one kind of animal, is due to iron starvation and can be cured and prevented by administration of an iron citrate. It is a possibility that there may be a general and widespread shortage of calcium, phosphorus, or of vitamin D, in the foods ordinarily consumed, or we may not eat sufficient of the food supplying these substances. If the supply of calcium or phosphorus or both is low in the food-supply, but vitamin D is adequate, it seems to effect a better utilization and economy of the calcium and phosphorus which are available, so that all three factors are important.

We have made some calcium determinations on foods, and have chosen those foods which, according to the analyses available from other countries are considered to be the most valuable and available sources of calcium, i.e., milk, cauliflower, carrot, and yellow turnip.

The calcium was determined by McCrudden's method (1) designed to quantitatively separate calcium and magnesium in the presence of phosphates and small amounts of iron, especially for analysis of foods, urine, and faeces. Each determination was done in duplicate or triplicate.

The following is a summary of results obtained compared with other data available:

### PERCENTAGE OF CALCIUM OXIDE.

<i>Milk</i>	% CaO	No. of Determinations.	Extremes.
Storms	.1761	11	.1642-.1872
Sherman	.168	Data gathered from many sources.	
Underhill	.179		
	.199		
Rose	.161		
	.165		
U.S. Dept. of Agriculture	.168		
Frank & Wang	.157	14	.1472-.167

	% CaO	No. of Determination.	Extremes.
<i>Carrot</i>			
Storms	.0576	7	.0453-.0772
Sherman	.0784		
Rose	.062		
Frank & Wang	.0683	13	.052-.0774
<i>Cauliflower</i>			
Storms	.0447	4	.0402-.0466
Sherman	.172		
<i>Yellow turnip</i>			
Storms	.0607	1	
Sherman	.1036		

Milk is an animal food, and we believe the mammal tends to keep a constant composition of the milk secretion even at a sacrifice of the parent tissues. Our determinations on milk agree with the average of those obtained elsewhere. Milk is the most practicable source of calcium not only for growing children but also adults.

Carrot, cauliflower, and yellow turnip all have a lower percentage of calcium so far as our determinations have gone.

Sherman's figures are those ordinarily used for dietary calculations. From studies made in our nutrition laboratory on dietaries actually consumed it appears that calcium is more apt to be below the standards which have been set than is any other one mineral substance. We are not yet able to calculate iodine content of foods. These standards have been set from human balance experiments, a considerable number of them done in different countries, and collected and summarized by Sherman. If in addition to an originally low calcium content in our foods we are figuring the calcium content of our dietaries using percentages higher than the actual content of calcium, then our calcium supply is even lower than we have calculated. If that is the case, it is no wonder the teeth suffer, and especially in cases of pregnancy.

It is therefore important to know the actual content of calcium in our foods and also to know exactly what is being eaten by the average family in the Dominion before we can state the condition of our diet with respect to calcium. Both of these lines of work are being carried on.

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## The Titre of New Zealand Mutton Tallows.

By A. M. WRIGHT, F.I.C., and IDA THOMPSON.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1926; received by Editor, 24th August, 1927; issued separately, 8th November, 1927.*]

THIS paper summarizes the results of several thousand titre determinations, which have been carried out over a period of seven years in the course of the daily examination of mutton tallows manufactured at a number of factories operating in both the North and South Islands of New Zealand.

The titre of a tallow, expressed usually in degrees Centigrade, is the solidifying point of the mixed fatty acids obtained by saponification and subsequent acidification of fats and oils; the basis of the actual determination of the titre lies in the fact that liquids during solidifying evolve heat (the latent heat of fusion) and a rise in temperature occurs; this rise, not marked in the case of fats and oils, is usually quite distinct with the fatty acids, and the temperature taken is the top point of the rise.

The method of determination used throughout in the results recorded in this paper was that officially recommended by the Association of Official Agricultural Chemists, the preliminary saponification being carried out with the glycerol-caustic potash solution.

The results of the investigation are shown in Tables 1 and 2.

In the fat and oil industries, the titre is of great importance, for upon the hardness of a tallow depends its use in various manufactured products, which include edible fats such as margarine, lubricating greases, soaps, and candles. It is outside the scope of this paper to discuss the various factors which determine the application of tallows of different degrees of hardness to certain specific industrial uses; but sufficient indication has been given as to the technical aspect of the titre in manufacturing processes.

Variations in the titre of a tallow, involve alteration in the proportion of stearin and of olein, and this from a chemical standpoint means a marked modification in the constitution of the animal fats, involving the relative amounts of saturated and unsaturated glycerides which are the component parts of the fats produced by the animal in the course of its nutritional functions; thus apart from the commercial aspect, the problems connected with the titre of animal fats are of fundamental importance from a physiological standpoint.

In general, the titre or hardness of a tallow is beyond the control of the tallow manufacturer, for it depends upon the breed, age, sex,



and the part of the animal from which the fat was removed, and to some extent upon the food of the animal; thus mutton fat is normally harder than beef fat, the fat from a mature animal is harder than that obtained from the younger animal, the fat from the male is generally harder than that from the female, the kidney fats are harder than the intestinal fats, animals fed on pasture generally yield a harder fat than those fed upon oil-cakes.

Throughout New Zealand, sheep and lambs derive their food almost exclusively from pasture and root crops, while oil-bearing feeding-stuffs are seldom if ever used to supplement the diet, hence the fats derived from these animals are largely formed from carbohydrates, but the chemical changes involved are still obscure. For all practical purposes the foodstuffs which constitute the diet of sheep and lambs are so similar throughout New Zealand as to introduce no material differences in the carbohydrates which are ultimately converted into fat within the animals.

In the tables, the reference to the mean Latitude South, indicates that of the works handling large quantities of stock for slaughter during a period varying each year from December to July inclusive; the range of Latitude South indicates the approximate latitudes within which most of the stock was received.

The maximum and minimum figures represent respectively the highest and lowest average for the period covered, thus in Table 1, for December-January, mean Latitude  $40^{\circ}$  S., the maximum of  $47.6^{\circ}$  for this period was in 1920, whilst the minimum  $45.5^{\circ}$  was in 1922; for February the maximum  $48.7^{\circ}$  was in 1925, the minimum  $48.0^{\circ}$  was in 1921; the seasonal maximum  $48.2^{\circ}$  was in 1925, the minimum  $47.2^{\circ}$  was in 1922. The average shows, in each instance, the numerical average for seven years.

No figures are given for the months August-November inclusive, for the reason that relatively a very small quantity of mutton tallow is manufactured during this period.

A study of the figures shows, as might be expected, that there is a gradual increase in the titre as the stock become more mature and older; in general, a certain peak is reached, and then some fall takes place, usually slight but definite; why this should occur at all seems obscure, for since the source of the fat is the carbohydrate content of the feeding stuffs, one does not expect a variation in the stearin-olein ratio to take place, as is indicated by the lower titre; there is the climatic factor, however, for usually the fall is more or less co-incidental with the onset of winter.

The figures also show that there is a definite relationship between the titre and the latitude; this is seen markedly when the seasonal average over seven years is compared with the mean Latitude from which the stock was drawn. For convenience these comparisons are shown in Table 3.

TABLE 3.

Mean Latitude S. Degrees.	Titre of Tallow.	
	Caul and Kidney Fats. Degrees.	Intestinal and Visceral Fats. Degrees.
40	47.9	44.1
41½	46.1	43.8
43½	45.8	43.0
44½	45.1	42.8
46	44.7	42.7

This table brings out clearly the fact that, the lower the Latitude degrees S., the lower is the average titre of fats from a corresponding portion of the animal. In the 40°—41½° mean latitudes the breeds differ to some extent from those in the 43½°—46° mean latitudes, but for the most part the differences in breed are not material when the average seasonal output is considered, nor do the carbohydrates from which the fats are built up materially differ.

Probably the differences are due to climatic variations, for in general the different latitudes have certain conditions as to rainfall, temperature, humidity, and sunshine, which vary from those found in other latitudes in the same country; but even when taking these factors into consideration, there are many anomalies and contradictory points which render any one explanation insufficient.

Information received from tallow brokers in Sydney indicates that similar variations as to latitude in Australia affect the titre of Queensland and New South Wales tallows.

For permission to publish this paper and results, acknowledgement is made to the New Zealand Refrigerating Company, Ltd., in whose laboratory the work has been carried out.

## Radium Emanation and Goitre Production.

(A negative result).

By R. R. D. MILLIGAN.

[Read before the Philosophical Institute of Canterbury, 3rd November, 1926; received by Editor, 31st December, 1926; issued separately, 8th November, 1927.]

### INTRODUCTION.

WHILE iodine deficiency in food, water, and air is recognized as the chief factor in the production of endemic goitre among human beings, it is not the only factor, since the percentage incidence of goitre varies greatly with sex, and also among individuals of the same sex, although the food supply is apparently identical.

It has been suggested that the presence of radium emanation might constitute another factor.

In 1925, before the Canterbury Philosophical Institute, Rogers read a paper on the occurrence of iodine and radium emanation in certain drinking waters in Canterbury. The object of his investigation was to see if a statistical correlation exists between the emanation content of the water, and the goitre census as disclosed by the medical examination of school children in these areas, and to compare this with the iodine content.

While Rogers found a close relationship between goitre incidence and iodine content—the less the iodine the more the goitre—he also found, with one marked exception, that the goitre incidence was directly proportional to the amount of radium emanation. The exception was the town supply of Timaru, where no emanation was found, although the goitre incidence was high. It was considered likely, however, that the emanation would be lost during transit by open race from the Pareora River.

Farr and Florance in 1909, and Farr in 1912, drew attention to the emanation content of certain Christchurch artesian waters and to a parallelism between that content and mortality in trout in the egg and yolk-sac stages. Aeration by rippling, waterfalls, and spraying, reduces this mortality. By these means, not only are dissolved gases such as nitrogen and argon liberated, but there is also a gain in oxygen. Carbon dioxide varies only slightly.

Again, of those trout that survive, a considerable number develop a protusion of the eyeball, "pop-eye". At a later stage some of the trout develop an enlargement of the thyroid gland, known to caretakers as "gill cancer", especially where the fish are rather crowded. Several "gill-cancers" on microscopic examination, showed a cellular proliferation of the thyroid similar to that seen in the human thyroids of Graves Disease. Protusion of the eyeball also occurs in Graves Disease, but while "pop-eye" in trout is apparently due to a collection of gas at the back of the orbit, a similar causation has not been proved for human beings.

These facts suggested that direct experiments with emanation were desirable, since a correlation curve at best could not prove causation. A search of the available literature on the pharmacology of radium emanation and salts of radium, gave no hint that thyroid disturbances could be caused by these agents, but since no record of

long-period experiments with large doses was found, it seemed possible that the thyroid effect may have been over-looked. It is significant, however, that in the fairly extensive literature of medical radiology, no record of goitre production could be found. The present report is merely a trial experiment on a total number of six rabbits. The experiment would have been continued with larger numbers had the results been encouraging, but it is believed that a more extended trial offers no hope of other conclusion than that reported here.

#### PROCEDURE.

The radium emanation was obtained by courtesy of the Wellington Hospital Board from the Radon plant in Wellington. Roughly, it was calculated that, allowing for loss in transit, a total of approximately 150 millicuries was administered to each of five of these rabbits and 100 millicuries to the sixth. Three of the rabbits were wild greys, three were white hutch rabbits, three were males, three were females. They varied from about two-thirds grown to full grown, but none were old rabbits. Three received their portion of the emanation in twelve weekly injections into the ear vein. The other three received the same amount by a stomach tube, except for one rabbit which died, probably of cardiac inhibition, while receiving the ninth dose. The ear rabbits received the emanation dissolved in 5 cc. of normal saline solution after crushing the capillary tubes containing the emanation underneath the solution. The stomach rabbits received the emanation liberated from the capillaries in 50 ccs. of saline solution. As radium emanation is very readily soluble, it was believed that the great bulk of the emanation would be present in the solution when prepared in this manner. Electroscopic tests made by Mr. Rogers in the Physics Department of Canterbury College showed that practically no loss of emanation occurred during the above procedure.

#### RESULTS.

The rabbits ate and thrived well and showed no abnormal symptoms. One became pregnant and produced three young rabbits, which are still healthy two months after the completion of the experiment. After thirteen weeks blood-counts and haemoglobin estimations were made and the animals were then killed. Four normal control rabbits were used to evaluate the changes that might be seen. Surprisingly, naked eye and microscopic examination of the main organs showed no abnormality, with the exception of a golden yellow degenerated liver in the case of the ex-pregnant female. The thyroids were neither altered in size as far as could be judged nor in microscopic appearances as compared with the controls. Certainly no appearances like those found in human goitre or in "gill-cancer" of trout were seen. The results were entirely negative as regards the production of thyroid abnormality or symptoms referable to the thyroid gland.

When it is remembered that these experimental rabbits received doses enormously greater than they could possibly receive during normal life it does not appear possible that emanation could be an important factor in the causation of goitre, at least among rabbits. Further, although it is true that different species vary considerably

in susceptibility to goitre production by iodine deficiency it is unlikely that the effect of massive doses of radium emanation would be remarkably different among mammals. The effect of radium emanation on yearling trout is also being tested out, but the results are not yet ready for publication.

## **The Kata-Thermometer Applied to the Investigation of the Physical Conditions of Schoolroom Atmosphere.**

By P. W. GLOVER, Physical Laboratory, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1926; received by Editor, 5th February, 1927; issued separately 8th November, 1927.*]

MODERN ideas concerning the suitability of atmospheric environment depend on the physical condition of the atmosphere, and it is interesting then to determine how the ventilation schemes in our schools conform with the standards set down by the modern authorities. In this paper are set forth the results of a series of observations of the physical conditions of the atmosphere in two types of schoolroom, the open-air type and the modern departmental type. The object of the investigation was to determine whether any appreciable difference exists between the atmospheric conditions prevailing in the two types of room due to the difference in the ventilating schemes. The observations were made over an interval of roughly one month in the period November—December 1925. The results set forth herein are to be considered only as preliminary, and by no means as final, since they require substantiation by further observations extending over a complete year at least. Nevertheless the author considers that they are indicative of the more general results to be obtained later. It is regrettable that circumstances which could not be controlled interrupted the investigation and prevented its continuance during the present year. However it is hoped to continue the work on a wider scale in 1927. The author believes that this is the first investigation carried on with the kata-thermometer in New Zealand.

Since the instrument used in this investigation is probably not well known, it has seemed advisable to preface the discussion of the observations by a brief outline of the physical principles of the kata-thermometer, together with a few remarks on the significance of the conditions measured with it from the standpoint of hygienic physiology. Most of that portion is really a restatement of the works of Hill, Griffith, Flack, Lefevre, and others, with the exception of the reduction of the observations to a standard condition of temperature, barometric pressure, and humidity, of which the author has seen no mention elsewhere.

### **PHYSICAL PRINCIPLES OF THE KATA-THERMOMETER.**

The kata-thermometer is an alcohol thermometer having a bulb of cylindrical form about 4 cm. long and 2 cm. diameter. The stem is about 18 cm. long, graduated by two marks the mean temperature

between which is  $36^{\circ}.5$  C. (body temperature), and has a small reservoir at the top to prevent bursting through overheating. Both dry and wet readings are taken, a wet stall covering the bulb in the case of the wet readings. The kata is heated until the alcohol enters the top reservoir. The time in seconds for the alcohol column to fall between the graduations is measured with a stop watch, and this divided into the factor for the instrument gives the rate of cooling of the atmosphere at the body temperature in milligramme-calories per square centimetre per second.

The rate of cooling of the dry kata clearly depends on radiation and convention, while that of the wet kata depends on these plus evaporation, so that by simple subtraction we can find the rate of cooling due to evaporation alone. Further it has been found that the rate of heat loss due to radiation  $H_r$  is equal to that due to convection ( $H_c$ ) i.e., for the dry kata, if  $H$  is the rate of cooling,

$$H = H_r + H_c = 2H_r = 2H_c$$

If  $V$  is the wind velocity in metres per second, and  $T$  the temperature in degrees centigrade of the medium in which the kata is placed, then it has been found by Hill and others that

$$V = \left\{ \frac{(H/(36.5-T)) - 0.27}{0.49} \right\}^2$$

which expression has been fully verified by observations made in wind tunnels and tubes of various dimensions.

If  $H_1$  is the cooling power at a temperature  $T_1$  and  $H_2$  that at temperature  $T_2$ , then the relation:—

$$H_2 = H_1 \left\{ \frac{36.5 - T_2}{36.5 - T_1} \right\}$$

has been amply verified by experimental evidence.

If  $H_1$  is the cooling power when the barometric pressure is  $p_1$  and  $H_2$  is the cooling power when the pressure is  $p_2$ , it has been shown and amply demonstrated by experiment that the following relation holds true:

$$H_2 = \frac{H_1}{2} (1 + \sqrt{p_2 / p_1})$$

In the case of the wet kata, we have to consider also the influence of humidity. If  $W$  is the rate of cooling of the wet kata,  $F$  the vapour tension in millimetres of mercury of air saturated at  $36^{\circ}.5$  C,  $f$  the tension of aqueous vapour in the air, and  $V$  the wind velocity in metres per second, the following equation has been shown to fit the facts adequately:—

$$W = (0.27 + 0.49 \sqrt{V}) (36.5 - (T)) + (0.085 + 0.102 V^{0.3}) (F - f)^{4/3}$$

Hence by simple subtraction, we have that  $H_e$  the rate of cooling due to evaporation is given by:—

$$H_e = (0.085 + 0.102 V^{0.3}) (F - f)^{4/3}$$

It is at once seen that by the use of these equations, readings taken with the kata-thermometer under one set of conditions can be reduced to their equivalents at a set of standard conditions. This reduction to standard conditions is very necessary if we wish to make a fair comparison between the efficiency of the ventilating systems in use at places some distance apart.

## PHYSIOLOGICAL CONSIDERATIONS.

There is an enormous collection of evidence which leads us to the conclusion that lack of fresh air has a marked deteriorating effect on the mental and physical powers of the human being. This effect has been ascribed to poisoning due to excess of  $\text{CO}_2$  or to exhaled organic matter of human origin or to both of these causes. Singly and collectively these ideas have proved inadequate. Three per cent. of  $\text{CO}_2$  can be endured without ill effect, and we know that the air sacs of the lungs contain from 5% to 6% of  $\text{CO}_2$ . The oxygen-content of the worst ventilated and most over crowded room is higher than that of the air at the Alpine health resorts. The idea of a subtle organic poison has been shown by exhaustive scientific tests to be wholly without foundation. The cause of the "stiffness" of crowded rooms has however been traced albuminous decomposition-products from buccal, nasal, and cutaneous surfaces, and clothing. The net result of the research performed of late years on this question, is that the evil effects of foul air are not due to chemical impurities acting through the lungs, but to physical changes acting through the skin. If the physical conditions of the air are such that equilibrium between the heat-production and loss is upset, heat-retention sets in which in its turn sets in operation chemical changes in the tissues which result in toxins producing fatigue, etc. This causes a further increase in temperature which increases oxidation processes leading in their turn to further heat-production. Evaporation from the skin enables us to cope with excessive heat-production from within and excessive heat-reception from without. Hence in order to determine the suitability of an atmospheric environment, we must determine the rate of cooling and the evaporative power of the air at the temperature of the body.

It was suggested to me that measurement of the standard metabolic rates of the children from the rooms under investigation would give an indication of the results of the two types of ventilation. This would have been very impracticable, and besides could hardly have led to any definite result, since the differences in the atmospheres of the two rooms turned out to be very small, and further it is customary to allow a 10% departure from the mean as a normal rate. In this connection we should remember, too, that in the examination of 1642 patients suffering from diseases other than thyroid disorders, Boothby & Sandiford found that the basal metabolic rate of 74% of these fell within the normal 10% range.

Various standards of suitability have been proposed from time to time by various investigators.

## WET BULB TEMPERATURE AS A STANDARD.

Haldane who studied the influence of wet and dry bulb readings on body temperatures, considered the wet bulb temperature to be a measure of the suitability of conditions. The wet bulb temperature should be low enough to ensure evaporation; and he stated maximum wet bulb temperatures for various types of factories, e.g., spinning mills, etc.

## DEW POINT AS A STANDARD.

Bruce showed that any attempt to judge conditions by the wet bulb temperature alone is certain to be misleading, a wet bulb temperature of  $28^{\circ}\text{C.}$ , being under certain conditions much more agreeable than one of  $24^{\circ}\text{C.}$  He found that when the dew point is between  $21^{\circ}\text{C.}$  and  $24^{\circ}\text{C.}$ , the conditions became very trying, but that in the neighbourhood of  $17^{\circ}\text{C.}$ , hard work can be carried on without inconvenience. He therefore fixed this as the maximum dew point for factories.

## WET KATA READING AS A STANDARD.

The rate of evaporation in the air is dependent upon:—

- (1) The tension of aqueous vapour in the air,
- (2) The tension of aqueous vapour in air saturated at  $36^{\circ}5\text{C.}$ ,
- (3) The velocity of the air current.

It is now considered that the kata succeeds where the wet bulb and dew point criteria fail as a standard of comfort. The evaporative power has a great effect on human energy, as has been proved by world-wide observation, and so from kata observations one may be able to judge whether a certain place is suitable for work of a certain type.

As minimum cooling powers Leonard Hill lays down the following:—

Dry kata	not less than	6 millicalories/second
Wet kata	not less than	18 millicalories/second

but it is argued that in the case of schoolrooms they should be:—

Dry kata	not less than	7 millicalories/second
Wet kata	not less than	20 millicalories/second

However these values were calculated for England where the mean annual temperature is about  $11^{\circ}\text{C.}$ , so that, if we reduce these to the condition of  $15^{\circ}\text{C.}$  (which is somewhere near the mean temperature for New Zealand) we have for the minimum for a schoolroom,

Dry kata	not less than	6 millicalories/second
Wet kata	not less than	16 millicalories/second

as a suitable standard for New Zealand.

## DISCUSSION OF RESULTS OF OBSERVATIONS.

The observations were made in the Open-air classroom at the Fendalton School, and in the Form 5 Room at the New West-Christchurch School. The open-air room is built with the sliding doors facing north-west, since, in spite of a popular superstition, the north-west wind is not a frequent one in Christchurch, the wind direction-frequency records of the Magnetic Observatory showing a total of only 315 days for north-west winds over a period of twelve years. The north-east side has five large windows swinging into a horizontal position about a central pivot, and above these five smaller similar windows. On the south-east side at the same level as these latter are five similar small windows, and on the south-west side are three similar small windows also at the same level. In the south

corner there is a fireplace for use in the cold weather. The sliding front consists of four slides which can be adjusted at will. The room measures 26 ft. x 24 ft. x 10 ft., and is designed to accommodate 60 children. The light entering the room through the open side does not have the ultra-violet rays filtered off by passage through glass. However, the windows were usually nearly all closed at the times when observations were made.

The room investigated at West-Christchurch is an upstairs one which would easily accommodate 60 pupils. The height is somewhat greater than that of the Fendalton room. The room faces approximately north north-west, and has a large window-area on this side. These windows can be opened to an angle of about 30 degrees about horizontal axis, and this condition prevails over almost the whole side of the room. On the opposite side is another set of windows: some large ones each opening to 90 degrees about a vertical axis and some hopper windows below these. On the other side of this wall is a corridor which again has a very full set of windows opening outside; but all the light passes through glass and so has the ultra-violet rays filtered off before it gets into the room. The heating is by means of steam radiators. It should be noted here that since the room is an upstairs one, the wind velocity affecting it is higher than that for a ground-floor room. The outside readings were taken standing on the ground, so that the outside wind velocities affecting this room were in reality a little higher than those given in the following results.

TABLE 1.  
Circumstances of the Observations.

A.—Fendalton.

No. of Obsn.	Date 1925	Time	Wind	Cloud	$\frac{C}{A}$	Remarks
1	18 Nov.	h. m. 14 15	N.E.	cum. str. 3	$\frac{50}{60}$	3 small windows open 0 large " " side open
2	23 Nov.	13 55	N.E.	cum. 7	"	" " "
3	24 Nov.	10 25	E.N.E.	cum. str. 3	"	0 windows open side open
4	30 Nov.	14 20	N.N.E.	cum. 9	"	3 small windows open 0 large " " side open
5	2 Dec.	9 35	S.W.	cum. 6	"	0 windows open side open
6	9 Dec.	13 40	E.N.E.	cum. str. 6	"	6 small and 1 large windows open; side open

B.—West Christchurch.

1	24 Nov.	9 40	E.N.E.	cum. str. 3	$\frac{43}{60}$	All possible ventilation
2	2 Dec.	13 50	S.W.	cum. 6	$\frac{25}{60}$	" " "
3	3 Dec.	10 15	E.	cum. 10	$\frac{35}{60}$	" " "
4	7 Dec.	14 5	E.	cir. cum. 4	$\frac{49}{60}$	" " "
5	8 Dec.	10 00	S.W.	cum. 9	$\frac{49}{60}$	" " "
6	10 Dec.	13 50	E.N.E.	cum. str. 6	$\frac{14}{60}$	" " "

In the above table, C = number of children in the room, and A = the accommodation of the room.

However, much more complete meteorological data were taken both inside and out for the purpose of reducing the results to a standard condition, namely, temperature =  $15^{\circ}\text{C}$ ., barometric pressure = 760 millimetres of mercury, and humidity = 70% (and therefore  $F - f_0 = 36 \text{ mm}$ , 76). The 70% humidity standard was chosen because the average humidity of Christchurch is in the neighbourhood of 70%.

The meteorological data collected in connection with the kata observations are set forth in the following table, in which the numbers of the observations correspond with those of the previous table.

TABLE 2.  
Meteorological Data.  
A.—Fendalton.

No.	1	2	3	4	5	6	Means
inside							
$P_1$ ...	764.3	748.8	751.8	750.5	755.1	754.2	754.1
$T_1$ ...	18.0	17.2	19.0	20.2	18.0	23.9	19.4
$T_2$ ...	13.0	13.9	13.8	14.8	13.2	17.8	14.4
R ...	56	67	55	53	57	52	57
$T_3$ ...	8.8	9.8	9.7	10.5	9.2	13.4	10.2
$F - f$ ...	36.8	35.7	36.5	36.0	36.8	34.0	36.0
outside							
$T_1^1$ ...	16.2	17.8	18.0	19.6	15.4	23.8	18.5
$T_2^1$ ...	12.6	14.4	13.6	14.2	11.8	18.1	14.1
$R^1$ ...	64	68	59	53	63	55	60
$T_3^1$ ...	9.3	11.7	10.0	9.9	8.6	14.3	10.6
$(F - f^1)$ ...	36.6	35.3	36.3	36.4	37.1	33.4	35.9
$(T_1 - T_1^1)$ ...	1.8	-0.6	1.6	0.6	2.6	0.1	0.9
$(T_2 - T_2^1)$ ...	0.4	-0.5	0.2	0.6	1.4	-0.3	0.3
$(R - R^1)$ ...	8	1	4	0	6	3	4
$(T_3 - T_3^1)$ ...	0	1.9	0.3	-0.6	-0.6	0.9	0.4
$(F - f) - (F - f^1)$ ...	0.2	0.4	0.2	-0.4	-0.3	0.6	0.1

B.—West Christchurch.

inside							
$P_1$ ...	751.8	757.8	756.6	757.4	756.3	749.8	755.0
$T_1$ ...	17.9	16.1	14.8	19.5	17.5	26.0	18.6
$T_2$ ...	12.8	10.5	12.2	14.9	14.8	16.1	13.6
R ...	55	50	73	59	72	35	57
$T_3$ ...	7.9	5.2	9.9	11.2	12.4	9.2	9.3
$(F - f)$ ...	37.5	38.9	36.3	37.4	34.7	36.8	36.9
outside							
$T_1^1$ ...	18.1	17.6	13.9	17.0	15.2	25.6	17.9
$T_2^1$ ...	13.0	12.1	12.3	13.8	13.4	15.8	13.4
$R^1$ ...	55	53	81	68	81	35	62
$T_3^1$ ...	8.2	7.5	12.3	11.0	12.3	9.3	10.1
$(F - f^1)$ ...	37.4	37.7	34.8	35.7	35.2	36.8	36.3
$(T_1 - T_1^1)$ ...	-0.2	-1.5	0.9	2.5	2	0.4	0.7
$(T_2 - T_2^1)$ ...	-0.2	-1.6	-0.1	1.1	1.4	0.3	0.2
$(R - R^1)$ ...	0	3	8	9	9	0	5
$(T_3 - T_3^1)$ ...	0.3	2.3	2.4	0.2	-0.1	0.1	0.8
$(F - f) - (F - f^1)$ ...	0.1	1.2	1.5	1.7	-0.5	0.0	0.7

In the above table  $p_1$  is the barometric pressure,  $T_1$  the dry bulb temperature,  $T_2$  the wet bulb temperature,  $T_3$  the dew point,  $R$  the humidity. The same symbols dashed are the corresponding outside values.

The meteorological data show that the mean inside temperature was 0.8 higher at Fendalton, and the outside temperature 0.6 higher. The inside wet bulb was 0.8 higher and the outside wet bulb 0.7 higher at Fendalton. The mean dew point was also higher at Fendalton by 0.9 inside and 0.5 outside. The differences between the humidities was of the same order as the probable error of observation, for it is very difficult to observe humidities to an accuracy of 1%. Further, the differences between the inside and outside mean dry bulb temperatures was 0.2 greater at Fendalton, and in the case of the wet bulb temperatures, 0.1 greater at Fendalton.

The following table gives the kata observations, both the observed values and the reduced values being recorded. They are in milligramme-calories per square centimetre per second correct to one place of decimals.

TABLE 3.  
Kata Observations.  
A.—Fendalton.

No. of Obsn.	Inside				Outside			
	Observed		Reduced		Observed		Reduced	
	$D_1$	$W_1$	$D_0$	$W_0$	$D_1^1$	$W_1^1$	$D_0^1$	$W_0^1$
1 ...	10.4	17.0	11.5	18.7	17.0	24.2	17.1	24.3
2 ...	8.0	14.7	8.9	16.8	8.4	14.9	9.7	17.7
3 ...	6.7	13.9	8.2	17.2	9.0	16.4	10.5	19.3
4 ...	8.1	14.1	10.7	18.9	9.8	18.7	12.4	24.0
5 ...	7.5	15.8	8.7	17.3	16.3	20.7	16.4	21.1
6 ...	6.2	15.2	10.5	27.7	8.5	20.9	14.3	38.4
Sums ...	46.9	90.7	58.5	116.6	69.0	115.8	80.4	144.6
Means ...	7.8	14.5	9.8	19.4	11.5	19.3	13.4	24.1
B.—West Christchurch.								
1 ...	7.5	13.9	8.7	16.0	13.4	21.9	15.7	25.5
2 ...	7.2	14.3	7.6	14.5	17.0	20.7	19.4	23.5
3 ...	8.1	13.9	8.0	13.8	11.5	17.7	10.9	17.3
4 ...	7.6	14.2	9.6	16.8	16.7	27.1	18.4	30.3
5 ...	8.0	13.2	9.1	15.4	16.2	22.8	16.4	23.4
5 ...	5.1	14.8	10.6	30.5	7.3	16.7	14.4	33.7
Sums ...	43.5	84.3	53.6	107.0	82.1	126.9	95.2	153.7
Means ...	7.3	14.1	8.9	17.8	13.7	21.2	15.9	25.6

From this table, considering the means of the reduced values, we have the following result:—

	Fendalton	West Christchurch
Evaporative power inside ... ..	9.6	8.9
Evaporative power outside ... ..	10.7	9.7
Diff. of cooling powers (out - inside) dry ... ..	3.6	7.0
"    "    "    "    "    " wet ... ..	4.7	7.8

It is immediately obvious from these results that the conditions in the open-air room are slightly better than those in the other room, as well as approximating more closely to the conditions prevailing outside.

Computing the wind velocity outside and the velocity of ventilation inside from the mean reduced dry kata readings, by means of the formula

$$V = \left\{ \frac{\frac{H}{36.5 - T} - 0.27}{0.49} \right\}^2$$

mentioned above, we have the following:—

School	Inside Velocity (Metres per second)	Outside Velocity (Metres per second)
Fendalton ... ..	0.1	0.5
WestChristchurch ... ..	0.1	0.9

Thus for the same wind velocity, the velocity of ventilation is higher in the open-air room than in the other in the approximate ratio of 2 : 1 when the ventilating system is fully open. If we group the observations made in the open-air room, taking those when all the windows were closed and those when only three small windows were open we find that the ventilation velocity in the first case was 0.1 metre per second, and in the second case 0.2 metre per second, which is the type of result one would expect according to the dictates of common sense.

The departures of these results from the minimum conditions as set down by Professor Leonard Hill, namely dry kata = 6, wet kata = 16 for the standard conditions of temperature, humidity and barometric pressure which we have adopted here are on the good side in the case of both rooms investigated. They are as follows:—

School	Excess above minimum requirement			
	Inside		Outside	
	Dry	Wet	Dry	Wet
Fendalton ...	3·6	3·4	7·4	8·1
West Christchurch ...	2·9	1·8	9·9	9·6

This shows clearly to what extent the conditions in the open-air room were superior to those in the other room. However, the difference is very small, even when we allow for the fact that the outside conditions were a little worse at Fendalton than at West Christchurch.

In considering the results, it is necessary to keep in mind the following facts:—

(1) An upstairs room was observed at the West Christchurch School, which must therefore be effected by a wind velocity a little greater than that at the ground—where the outside observations were taken—and hence have a ventilation velocity slightly greater than would otherwise be the case.

(2) The room at West Christchurch always had all the windows open to the fullest extent, which was by no means the case at the Fendalton room.

(3) The average ratio of the number of pupils to the available accommodation was 33/60 in the case of the West Christchurch room and 50/60 in the case of the Fendalton room.

#### GENERAL CONCLUSIONS.

To summarize these results, we have:—

(1) Higher cooling power of the atmosphere under the same conditions of temperature, humidity and barometric pressure in the open-air room than in the other.

(2) The ventilation velocity was greater in the open-air room than in the other with the same external wind velocity, and without irritating draughts, which is an important feature.

(3) The conditions in the open-air room were a closer approach to the outside conditions than were those in the other room.

(4) Both rooms conformed to the standard set down by Prof. Hill.

However it will be noticed that the difference between the cooling powers was so small that any advantages which might be represented could easily be vitiated by conditions of clothing, diet, and muscular activity; in fact one could more than compensate for the difference by shaving the heads of the children in the room

at West Christchurch, or by sending them to school without stockings. The greatest advantage of the open-air room would seem to be that due to the as yet not properly understood physiological qualities of the sun's rays, which qualities are apparently concentrated in the ultra violet or high frequency part of the spectrum. These ultra violet rays are filtered out by passage through ordinary window glass, but can be effective in their action in the open-air room from which they are not screened. The question of the effect of the open-air room on the basal metabolic rate, or as Krogh more aptly terms it standard metabolism, has already been disposed of. Increasing this is not desirable, since high metabolic rates are found mainly in diseased conditions such as exophthalmic goitre. In any case the difference of the metabolic rate due to the difference of atmospheric conditions could not possibly be detected with any certainty, since it is usual to consider variations of plus or minus 10% as normal in the measurement of basal metabolic rates.

These results are only of a preliminary nature, and it is the author's intention to carry on the investigation continuously throughout the year 1927, in order either to verify or to disprove the results set forth in this present paper.

In conclusion, the author desires to thank Dr. R. B. Phillipps, Dr. R. R. D. Milligan and H. F. Skey, Esq. M.Sc., for much valuable albeit at times harsh criticism during the preparation of this paper.

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## Mollusca from Twenty-three Fathoms off Ahipara, N.Z.

By A. W. B. POWELL.

[Read before the Auckland Institute, 9th November, 1926; received by  
Editor, 31st December, 1926; issued separately,  
8th November, 1927.]

(PLATE 34.)

DURING July, 1925, Mr. W. La Roche, of Auckland, received from Mr. D. Crawford, then engineer on the steam trawler "Serfib," a fine haul of mollusca from 23 fathoms off Ahipara Bay. The writer is indebted to Mr. La Roche for his kindness in making the material available for study and in donating the types. About a gallon of shells and shell fragments were secured. Apparently the material was held tightly together in the net by pressure of the fish; the passage through the water being only sufficient to remove all sand and mud. No doubt most of the minute species were lost in this way. The outstanding feature of the trawl was the extraordinary abundance of both *Dentalium nanum* and the new *Turritella* described in this paper. Fifty-one species, including five new ones were found, and are listed below.

Palaeontological workers in New Zealand are greatly handicapped through lack of recent deep-water faunal lists.

Murdoch and Suter (10), Hedley (3), and Webster (15), each contributed papers on an important dredging excursion made during 1904 in 110 fathoms off the Great Barrier Island. Several species previously known only as Pliocene fossils were represented, and the whole dredging furnished a convenient comparison with the Castlediff series, in determining the approximate depths at which the beds were deposited. \* Marshall (9 p. 91) estimated that depth at approaching 100 fathoms.

The Ahipara dredging, being the first from the West Coast of New Zealand to be reported on, opens up more possibilities regarding the Castlediff fauna, particularly as the bulk of the material was dredged in a fresh state, thus indicating more accurately the stations of species hitherto found only as dead shells, from various depths. This 23 fathom haul included the following 8 species: (*Eulima bulbula*, *Asperdaphne murrea*, *Marginella fusula*, *M. hebesceus*, *Tornatina tenuilirata*, *Coluzea spiralis*, *Epideira nodilirata* and *Acteon craticulatus*) previously recorded only from 110 fathoms off Great Barrier Island, with exception of the latter two, which have been recorded also from off Cuvier Island in 37-44 fathoms.

The above indicates that our deeper-water species do not occupy narrow zones, so that any one species cannot be taken as always representing a definite depth.

From solely a faunal argument therefore the Castlediff beds in the light of the Ahipara results are just as typical of depths between 20-25 fathoms.

LIST OF MOLLUSCA FROM 23 FATHOMS OFF AHIPARA.  
(All were in fresh condition except where otherwise stated).

GASTEROPODA.				Number and Condition of Specimens.
<i>Spectamen</i> (7 p. 227) <i>egena</i> (Gould)	....	....	....	Common.
<i>Zeradina odhneri</i> n. sp.	....	....	....	12.
<i>Nozema</i> (6, p. 452) <i>emarginata</i> (Hutton)	....	....	....	1.
<i>Turritella</i> ( <i>Zeacolpus</i> , 3, p. 388) <i>ahiparana</i> n. sp.	....	....	....	Very common.
<i>Uber</i> ( <i>Euspira</i> ) <i>vitreus</i> (Hutton)	....	....	....	2.
<i>Cochlis</i> (7, p. 254) <i>zelandica</i> (Q. & G.)	....	....	....	Common.
<i>Globisinum</i> (8, p. 573) <i>undulatum</i> (Hutton)	....	....	....	3 juveniles.
<i>Phalium</i> cf. <i>pyrum</i> (Lam.)	....	....	....	6 juveniles.
<i>Architectonica reevei</i> (Hanley)	....	....	....	1 (broken in trawl).
<i>Scala</i> (3, p. 401) <i>bucknilli</i> (Powell) (14, p. 138)	....	....	....	Common
" <i>jukesianum</i> (Forbes)	....	....	....	15.
" <i>philippinarum</i> (Sowerby)	....	....	....	1.
" <i>zelebori</i> (Dunker)	....	....	....	3.
<i>Syrnola crawfordi</i> n. sp.	....	....	....	3.
<i>Odostomia incidata</i> Suter	....	....	....	3.
" <i>georgiana</i> Hutton (3, p. 405)	....	....	....	3.
<i>Eulima bulbula</i> Murdoch & Suter	....	....	....	12.
<i>Coluzea</i> (3, p. 407) <i>spiralis</i> (A. Adams)	....	....	....	3 adults and 8 juveniles.
<i>Microvoluta biconica</i> (Murdoch & Suter), (3, p. 410)	....	....	....	6.
<i>Aeneator attenuata</i> n. sp.	....	....	....	1.
<i>Austrofusus glans</i> (Bolten), (2, p. 232)	....	....	....	Common (worn shells).
<i>Zeatrophon</i> (3, p. 424) <i>ambiguus</i> (Philippi)	....	....	....	7.
<i>Xymenella</i> (3, p. 424) <i>pusilla</i> (Suter)	....	....	....	Common.
<i>Alcithoe depressa</i> (Suter)	....	....	....	3 juveniles.
<i>Ancilla</i> ( <i>Baryspira</i> ) <i>australis</i> (Sowerby)	....	....	....	3 worn shells.
" " <i>mucronata</i> (Sowerby)	....	....	....	1 worn shell.
" " <i>novae-zelandiae</i> (Sowerby)	....	....	....	Common.
<i>Marginella fusula</i> Murdoch & Suter	....	....	....	3.
" <i>hebesceus</i> Murdoch & Suter	....	....	....	1.
<i>Epideira</i> (1, p. 515) <i>nodilirata</i> (Murdoch & Suter)	....	....	....	3.
<i>Phenatoma</i> (1, p. 515) <i>novae-zelandiae</i> (Reeve)	....	....	....	Common.
" (Cryptomella), (1, p. 516), n. sp.	....	....	....	Common.
<i>Melatoma</i> (5, p. 250) <i>buchanani maorum</i> (Smith)	....	....	....	Common.
<i>Fenestrosyrinx nezilis bicarinatus</i> (Suter), (2, p. 254)	....	....	....	3.
<i>Asperdaphne dictyota</i> (Hutton)	....	....	....	Common.
" <i>amoena</i> (Smith)	....	....	....	Common.
" <i>murrhea</i> (Webster)	....	....	....	5.
<i>Rugobela ahiparana</i> n. sp.	....	....	....	1.
<i>Pervicacia</i> (7, p. 262) <i>tristis</i> (Deshayes)	....	....	....	6 (worn shells).
<i>Acteon craticulatus</i> (Murdoch & Suter)	....	....	....	4.
<i>Pupa alba</i> (Hutton)	....	....	....	Common.
<i>Tornatina tenuilirata</i> (Suter)	....	....	....	1.
<i>Rhizorus nesentus</i> Finlay (3, p. 438)	....	....	....	1.
<i>Cylichnella thetidis</i> (Hedley)	....	....	....	2.
<i>Philine constricta auriformis</i> , Suter	....	....	....	1.
SCAPHOPODA.				
<i>Dentalium nanum</i> , Hutton	....	....	....	Very common.
PELECYPODA.				
<i>Nuculana bellula</i> (A. Adams)	....	....	....	1 valve.
<i>Macoma huttoni</i> (Smith)	....	....	....	1.
<i>Macra scalpellum</i> Reeve	....	....	....	2 valves.
<i>Memocardium pulchellum</i> (Gray)	....	....	....	1.
<i>Saxicava australis</i> Lamarck = ( <i>S. arctica</i> (Linn.) of Suter)	....	....	....	1.

\*Mr. H. J. Finlay is describing this species from elsewhere.

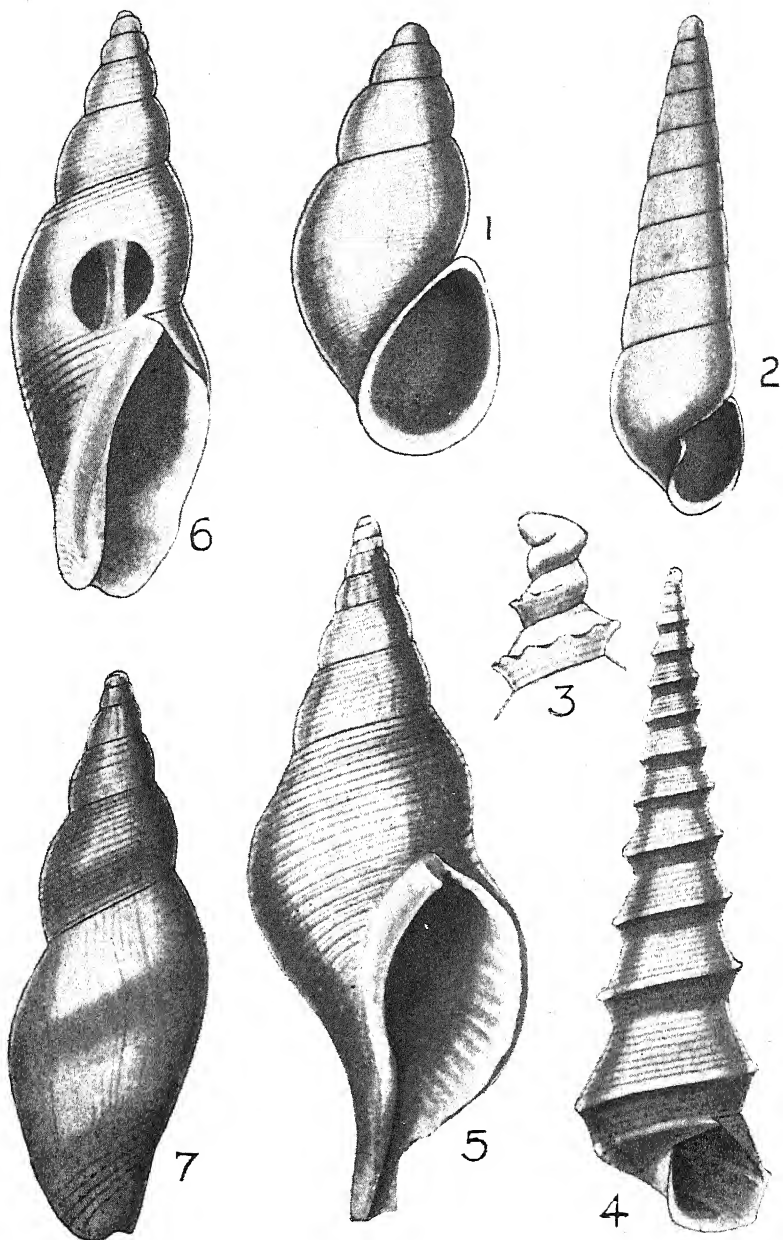


FIG. 1.—*Zeradina odhneri*, n. sp. (Holotype).  
 FIG. 2.—*Syrnola crawfordi*, n. sp. (Holotype.)  
 FIG. 3.—*Coluzea spiralis* (A. Adams). (Protoconch.)  
 FIG. 4.—*Turritella (zeacolpus) ahiparana*, n. sp. (Holotype).  
 FIG. 5.—*Aeneator attenuata*, n. sp. (Holotype.)  
 FIGS. 6 and 7.—*Rugobela ahiparana*, n. sp. (Holotype.)



**Zeradina odhneri** n. sp. (Fig. 1).

Shell small, thin, elongate-ovate, dull white. Protoconch dome-shaped, rather large of  $1\frac{1}{4}$  smooth glassy whorls. Whorls  $4\frac{1}{2}$ , separated by a deep suture. Spire a little higher than aperture, with convex outline. Sculpture consisting of exceedingly fine and numerous regular spiral striae, indistinctly reticulated by fine and close thread-like axial growth-lines. Aperture narrowly ovate, angled above and broadly rounded below. Peristome thin, continuous, separated from parietal wall. Outer lip flexuous, retractive below suture for a short distance, forming a broad shallow sinus, then protractive below centre of whorl.

Height 4.5 mm.; diameter 1.4 mm. (holotype)

„ 4.0 mm.; „ 1.0 mm. (paratype)

Holotype and 4 paratypes in Author's collection, Auckland.

*Remarks*: Closely related to Odhner's *Fossarus ovatus* (13, p. 18) but differs from that species in being much larger and yet proportionately narrower with a slightly taller spire. Odhner's *F. productus* (13, p. 19) is also a related species.

**Turritella (Zeacolpus) ahiparana** n. sp. (Fig. 4).

Shell moderately large, elevated, many-whorled, spire with a single strong, smooth, spiral keel. Protoconch of two smooth rounded whorls. Whorls 14. First post-nuclear whorl starting with a sharp angle at middle, rapidly developing into a strong spiral keel, which increases in size and becomes lower down in succeeding whorls. With exception of a second keel on base, proceeding from suture the only remaining sculpture consists of very fine and uniform spiral striae, which covers the whole of post-nuclear whorls and base, with exception of keels, which are smooth and rounded. Aperture subquadrate. Outer lip thin and sharp with broad shallow rounded sinus. Columella vertical, thin. Parietal wall with thin spreading glaze. Colour, dull reddish-brown; protoconch, first post-nuclear whorls, spire, and basal keels lighter; base slightly darker. No colour-pattern or mottling. Height, 23.25 mm.; diameter, 7 mm. (Holotype).

*Holotype* and many paratypes in author's collection, Auckland.

*Remarks*: *Turritella pagoda* Reeve, is the closest related species, which, however, differs in having a second spiral about half the strength of the main keel, at upper third of whorls. The main keel is not nearly so prominent as in *ahiparana*. The colour pattern of *pagoda* (reddish-brown streaks on a pale ground), is entirely wanting in *ahiparana*, which is uniformly dull reddish-brown.

Although *ahiparana* was extremely common in this dredging it is apparently quite local in distribution as I have not found it in any other northern dredging.

**Syrnola crawfordi** n. sp. (Fig. 2).

Shell small, elongated, smooth and polished. Whorls 8 plus a heterostrophe, sinistral, convoluted protoconch of  $2\frac{1}{2}$  whorls, with a horizontal axis. Colour white. Surface of shell appearing smooth and polished but showing under microscope extremely fine spiral

striae. Spire high  $3\frac{1}{4}$  times height of aperture, outlines straight, body-whorl rounded at periphery. Suture deeply impressed. Aperture elongate-ovate, angled above and narrowly rounded below. Outer lip thin and sharp. Columella vertical, slightly arcuate with small plait above. Base rounded with slight umbilical chink behind columellar fold.

Height, 5.25 mm.; diameter, 1.45 mm.

*Holotype* in writer's collection and one paratype in collection of Mr. W. La Roche, Auckland.

*Remarks*: Closely related to *S. lurida* (Suter) from off Cuvier Id. in 38 fathoms. From *crawfordi* nov, *lurida* differs in having whorls faintly convex in outline and more rapidly increasing, protoconch of but one globose whorl and protoconch plus 7 adult whorls in a length of 6 mm., whereas *crawfordi* has 8 adult whorls plus protoconch in 5.25 mm. Named in honour of Mr. D. Crawford who secured the material on which this paper is based.

### *Coluzea spiralis* (A. Adams).

As a synonym of this species E. A. Smith's *Columbarium suteri* (15 p. 87) should be added.

A fine series of *C. spiralis* were represented in the Ahipara dredging, ranging from juveniles of 3 whorls up to perfect fresh adults. Unfortunately the soft parts were not preserved by the collector. A specimen of 6 whorls agrees in every particular with Smith's description of his *Columbarium suteri*, founded on a single example of 6 whorls, and also with the specimen ascribed to this species by Miss Mestayer from 98 fathoms of Big King Id. Three Kings Id. (10 p. 126). The exact generic place must remain in doubt until the radula of *spiralis* is known as the shells of *Columbarium* and *Coluzea* (*Fusinus*) are remarkably similar.

Lieut.-Colonel A. J. Peile has published (Pro. Mal. Soc. XV., 1922 pp. 18, 19, fig. 1) a new figure of the radula of *Columbarium*. He withdraws the genus from the *Turridae* and refers it to the *Rachiglossa* near *Muricidae*.

The figure (fig. 3) represents the protoconch and first post-nuclear whorls of an Ahipara specimen.

### *Aeneator attenuata* n. sp. (Fig. 5).

Shell moderately large, solid, elongate, fusiform, whorls lightly convex, spire and canal produced. Protoconch rather small of  $2\frac{1}{2}$  smooth rounded whorls. Whorls 8 rapidly increasing. Spire tall, almost equal to height of aperture plus canal. Outline of whorls lightly convex but with a shallow depression just below upper suture, body-whorl inflated at middle. Suture deep, appressed. Post-nuclear sculpture, continuing over base and canal, consisting of numerous fine spiral cords (14 on penultimate whorl) with single fine spiral thread in each intercostal space. First  $2\frac{1}{2}$  post-nuclear whorls with strong, close, rounded axial costae, absent on succeeding whorls, the only axial sculpture being fine flexuous growth-lines.

Aperture ovate, produced below into rather long open canal, curved slightly towards left. Peristome discontinuous. Outer lip strong, flexuous, lirate within, with a broad shallow sinus extending from just below suture to periphery. Inner lip with a linear denticle marking off anterior canal. Columella concave, covered with rather thick callus separated from body-whorl by a groove running right to extremity of canal. Outer lip of canal broken away in holotype, the only known specimen.

Holotype in author's collection, Auckland.

Height, 53 mm.; diameter, 20.5 mm.

*Remarks:* This species is quite distinct from the Castlecliff *A. marshalli* Murdoch (12 p. 159), which also occurs recent. *A. attenuata* differs from *marshalli* in having a proportionately much taller spire with whorls not so inflated but more finely sculptured with more numerous spiral cords, also with axial sculpture nearly obsolete, confined to the first two or three post-nuclear whorls only.

### ***Ancilla (Baryspira) novae-zelandiae* Sowerby.**

The average height of this species is 8 or 9 mm. Occasional specimens from deep water in northern parts of New Zealand attain almost double this height. A series of 26 specimens were obtained in the Ahipara dredging, of which number only six were 9 mm. or less in height. The two largest were 16.5 mm. (height)  $\times$  7.5 mm. (breadth) and 16.75 mm.  $\times$  8 mm. respectively.

Excepting the much larger adult size there are no differences on shell characters between these large forms and the smaller typical species. *Ancilla australis* is subject to similar discrepancies in adult size according to habitat, and also *Ancilla mucronata*, the average height of which is about 30-40 mm. I have a specimen of this latter species from Mount Maunganui, Bay of Plenty, measuring 60 mm. in height.

The spire-callus is also extremely variable in the genus. Several of the large *A. novae-zelandiae* from the Ahipara dredging have great swollen spires exceeding in width the maximum diameter of their respective body whorls.

### ***Rugobela* (3, p. 514) *ahiparana* n. sp. (Figs. 6 and 7).**

This shell is temporarily ascribed to *Rugobela* for lack of a better location. A single imperfect specimen was obtained, complete enough to furnish a recognisable description of the species, but hardly sufficient for founding a new genus.

Shell small, narrowly fusiform, thin. Protoconch of  $2\frac{1}{2}$  smooth, white, globose whorls. Whorls  $5\frac{1}{2}$ , lightly convex, rapidly increasing. First post-nuclear whorl with indistinct spiral sculpture and faint axial growth lines, following whorl with six distinct spiral riblets, the lower three closer together than upper three; penultimate whorl with about 20 riblets; body whorl with sculpture only faintly indicated, except eight stronger spirals on base, with channelled interstices, and the first few from the upper suture, similarly channelled but not quite so deeply. Basal sculpture stopped by fasciole. All

post-nuclear whorls crossed by faint, flexuous, irregular, axial growth-lines, most conspicuous on base and fasciole. Spire same height as aperture. Aperture high and narrow with a short, broad open canal. Outer lip broken. Columella vertical, curved forward slightly at base. Parietal wall smooth, convex, slightly excavated. Fasciole rounded, imbricated by growth lines. Colour pale buff, with an indistinct, broad peripheral and a basal band of a slightly darker colour.

Height, 8.25 mm.; diameter, 3 mm.

Holotype in author's collection, Auckland.

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## Descriptions of the Immature Stages of some New Zealand Crane-flies: Part 1.

By J. SPEED ROGERS, University of Florida, Gainesville,  
Fla., U.S.A.

(Communicated by A. L. TONNOIR, Cawthron Institute, Nelson.)

[Read before the Nelson Philosophical Society, 28th September, 1927;  
received by Editor, 29th September, 1927; issued separately,  
8th November, 1927.]

THROUGH the kindness of my friend, Dr. C. P. Alexander, of Amherst, Mass., I have received an important collection of immature stages of New Zealand crane-flies. These larvae and pupae were sent to Dr. Alexander by Messrs. Tapely, Gourley, Harris, Highway, Campbell, and Lindsay of New Zealand, who, in the majority of cases had reared a part of the specimens and so made identification of the larvae and pupae possible. The identifications of these reared imagoes are due to Dr. Alexander. I wish to express my gratitude to Dr. Alexander and the several New Zealand entomologists named above, for the opportunity to study this well-preserved and valuable material, which includes larvae and pupae of several genera whose immature stages were unknown.

The present instalment of these descriptions is concerned with the identified immatures of the genus *Macromastix* Osten Sacken, one of the genera whose larval and pupal stages remain undescribed.

### *Macromastix albigma* Edwards.

#### *The Egg.*

Length, 0.75 mm.; diameter at midlength, 0.45 mm. Form short, rounded elliptical. Chorion rigid, tough, unsculptured; in alcoholic specimens, dull brownish black, the smooth surface rather opaque.

#### *The Larva.*

Length, 16.5-20 mm.; diameters of the 2nd abdominal segment: dextro-sinistral, 6-6.5 mm.; dorso-ventral, 5 mm. Form robust, moderately flattened dorso-ventrally, oval in cross section. Body thickest in region of first three abdominal segments; thoracic and posterior abdominal segments of about equal depth and breadth; anterior and posterior extremities blunt.

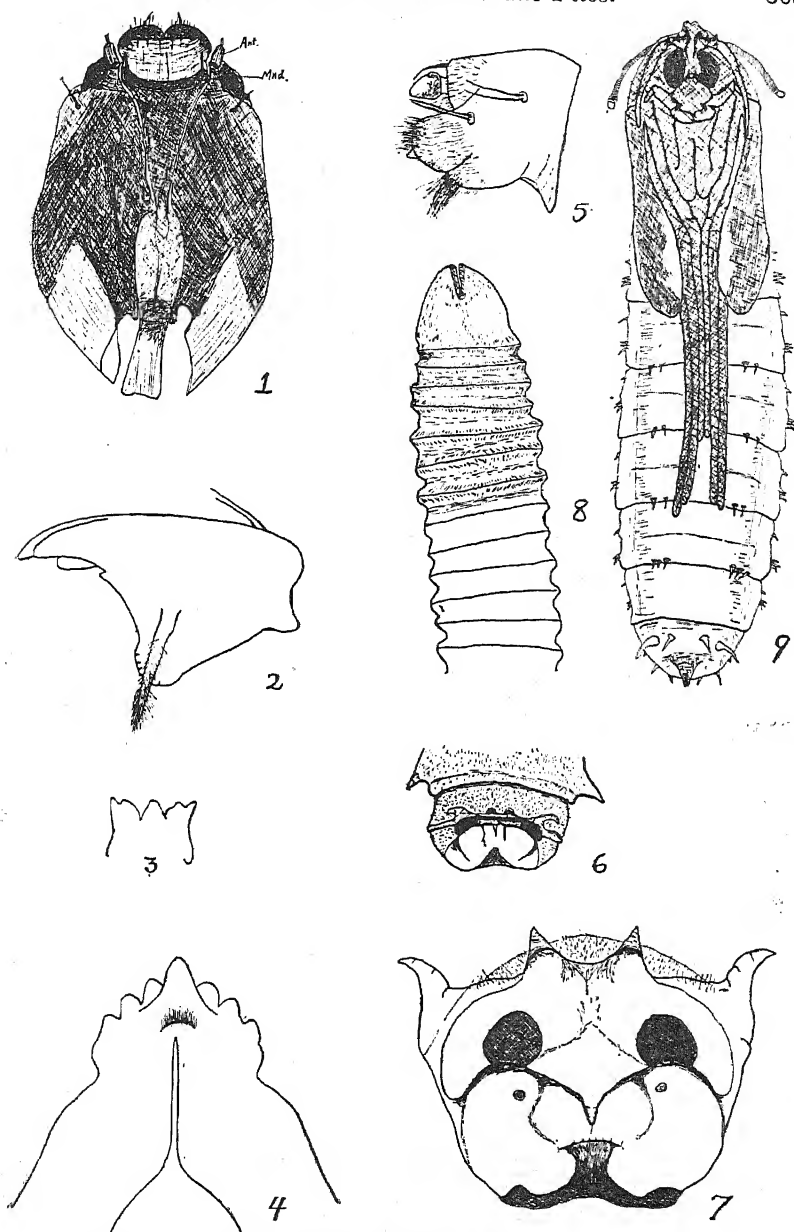
Colour (alcoholic specimens), a dull cinnamon-buff, somewhat darker on dorsum of thorax. Integument opaque, leathery, tough; bearing an even, moderately dense, growth of minute hairs nearly concolourous with integument. Setae small, weak, inconspicuous; when broken the setigerous punctures hardly evident. The abdominal somites are divided into anterior and posterior annuli, the former with several transverse wrinkles across dorsum, the latter somewhat the longer and more smooth. Abdominal segments 7 and 8 with a caudo-

laterally directed, fleshy tubercle at each caudo-lateral margin. (Those of segment 8 shown in fig. 6). Segments 5 and 6 have very minute tubercles in the same positions.

Spiracular disk dorso-caudal. When expanded (fig. 7) occupy dorsal half of caudal aspect; when contracted (fig. 6) visible only as a transverse dorsal slit at about two-thirds the length of 9th abdominal segment. Of the six lobes borne by disk, the ventral pair are very large and fleshy, almost fused in median line; their apical margins with brown, chitimized lines. When disk is expanded the faces of ventral lobes are at right angles to vertical face of disk proper and form a horizontal shelf whose area is equal to that of disk. In contracted condition the faces of ventral lobes are turned upward to a nearly vertical position, concealing spiracles and face of disk, and in this position the fleshy caudo-ventral faces of ventral lobes form a tumid caudal end to the larva. From the middle of the caudo-ventral face of each lobe is borne a small, cylindrical, fleshy papillus. The disk proper is sub-quadrangular, the long dimension of quadrangle, dextro-sinistral. The nearly circular spiracles are dark brown, their centres a dead black; they are separated by about once and a half times diameter of one spiracle. The slender, conical, dorso-lateral lobes project dorsad from dorso-lateral angles of disk and at about mid-length turn abruptly laterad; the caudal face of their bases has a chitimized, faint brown line. The paired dorso-median lobes are very small, rounded, chitimized projections to either side of dorso-median line. From cephalic surface of each arises a small, fleshy, conical papillus that projects dorsad well beyond lobe itself. Save for the spiracles and chitimized areas noted, disk is concolourous with rest of abdomen.

The anal gills have the form of a broad circum-anal ring that is radially wrinkled, and are opaque white save for a dark brown, chitimized outer portion. When gills are retracted only this chitimized outer portion is visible. Apparently the gills serve as an organ of locomotion.

Head capsule (fig. 1), broad, massive, compact, heavily chitimized. Length, 3.5 mm.; breadth, 2 mm.; greatest depth (mid-length of lateral plates), 1.3 mm. Prefrons a long narrow triangle, its slightly concave base forming anterior margin, posterior apex slender, elongate; anterior two-thirds heavily chitimized, dark brown. Lateral plates mussel-valve-like in shape; anterior three-quarters and entire margin heavily chitimized, dark brown; the centre of posterior quarters membranous, yellowish brown, ventro-mesal anterior margins projecting to form the bars of mentum, toward lateral angles of dorsal cephalic margins with a single stout, long seta. Clypeus shallow crescentic, chitimized, dark brown; cephalo-lateral horns with a single, erect, brownish yellow seta. Labrum epi-pharynx rectangular, almost square; a transverse groove caudad of its cephalic margin; back of this groove the surface is slightly depressed, saucer-like, conspicuous whitish yellow; anterior to groove with cephalo-lateral margins chitimized, dark brown, bearing numerous long, stiff hairs and a pale slender papillus-like rod, the median cephalic portion emarginate. Antennae with first joint stout, cylindrical, dark brown except for yellow apex; 2nd joint minute, elongate oval, yellowish white. Man-



1. Head capsule of larva, *Macromastix albistigma* Edw.
2. Mandible of larva, *M. albistigma* Edw.
3. Hypopharynx of larva, *M. albistigma* Edw.
4. Mentum of larva, *M. albistigma* Edw.
5. Maxilla of larva, *M. albistigma* Edw.
6. Ninth abdominal segment and contracted spiracular disk of larva, from above, *M. albistigma* Edw.
7. Expanded spiracular disk of larva, caudal aspect, *M. albistigma* Edw.
8. Pronotal breathing horn of pupa, *M. albistigma* Edw.
9. Pupa of *M. albistigma* Edw., ventral view.

dibles (fig. 2) stout, heavily chitinized; three blunt, cylindrical, apical, teeth, median tooth the largest and curved slightly mesad; a minute elevation at the base of dorsal tooth; dorsal margin near base of mandible, rounded, protruding, the crest of this protuberance minutely crenate; remainder of mandible smooth, the edges rounded; a pair of long setae borne from a common pit on proximo-lateral angle of ventral face. Prosthecal appendage a long, hairy papillus with a tuft of longer, yellow hairs at its apex. Maxillae (fig. 5) smaller than mandibles, flattened, sclerites distinct. Cardio large, sub-quadrangular, a pair of long, erect hairs borne from a common depression near middle of its anterior ventral face. Stipes a short, thick cylinder, slightly dilated distally, its proximal margin very oblique; apically it bears a prominent, conical palpal joint and, just before apex, a long stout seta that curves toward tip of palpus. Outer lobe short and stout with a pair of setae from a common pit at base of ventral surface; the rounded apex with a dense growth of yellow hairs and, on inner surface, a small chitinized cone. Inner lobe smaller, flattened triangular, and bears a small tuft of hairs directed meso-cephalad. Mentum (fig. 4) broad, prominent, barely constricted back of bases of lateral teeth; median tooth long, projecting; to either side three lateral teeth, smaller and flatter than median tooth; caudal cleft extends cephalad to a point opposite bases of second lateral teeth. Hypopharyngeal plate (fig. 3) narrow, anteriorly with a triangular median tooth and a pair of broad, incompletely double lateral teeth.

#### *The Pupa* (Figs. 8, 9 and 11).

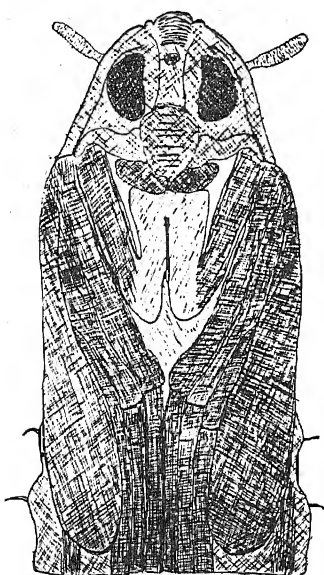
Length, 17-19.5 mm.; diameters at base of wing-pad: dextro-sinistral, 3.5 mm.; dorso-ventral, 3.7-4 mm.; width of 5th abdominal segment, 5-5.5 mm.

Form cylindrical in the thoracic region, the head irregularly conical, the abdomen flattened dorso-ventrally, markedly so in the pleural region.

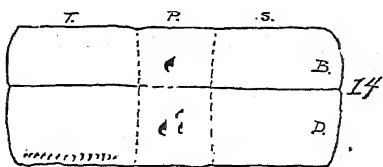
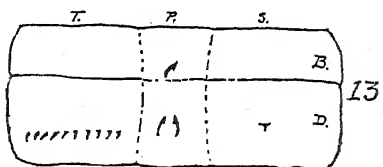
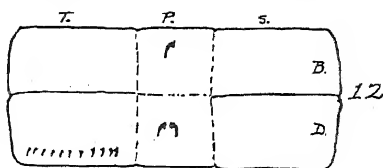
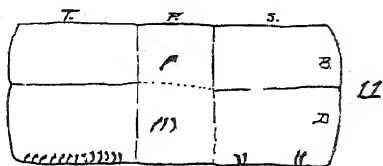
Colour (alcoholic specimens): the older pupae dark brown save for the pronotal breathing-horns, the stigma region of the wing-pads and the central portions of the basal abdominal segments which are yellow or orange yellow; in the younger pupae the yellow is much more extensive, the brown restricted to margins of sclerites, eyes, and face.

Head terminating anteriorly in a large, blunt, irregularly conical tubercle, ventro-cephalic face of this tubercle sculptured with transverse chitinous ridges. The antennae arise immediately ventrad to base of cephalic tubercle, the space separating their bases narrow; they curve first dorsad along bases of tubercle, then caudad around eyes to terminate at a little less than a fourth the length of the wing-pad. Each antennal base is ornamented with several prominent, acute, conical points; of these the middle pair is the largest, wholly chitinized, dark brown, their apices slightly divergent; the members of the next pair are small, slightly caudo-lateral to the first; the third pair is intermediate in size, their bases laterally compressed. Cheeks flattened, their caudo-lateral margins projecting as acute lobes. Front moder-

ately broad. Labrum large, its surface broadly convex, with a small rounded elevation bearing two chitinized points near its mid-proximal point; bluntly constricted before apex which ends in an obtuse point. Labial lobes barely contiguous medially, roughly subquadrate. Maxillary palpi elongate, narrowing to acute tips; they extend along ventral margin of cheeks to antennal sheaths where they bend caudad and extend for a short distance contiguous and parallel to antennal sheaths.



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10. Pupa of *M. dichroithorax* Alex., ventral view of anterior end.
11. Diagram of spine arrangement of fifth abdominal segment of pupa of *M. albistigma* Edw.
12. Diagram of spine arrangement of fifth abdominal segment of pupa of *M. dichroithorax* Alex.
13. Diagram of spine arrangement of fifth abdominal segment of pupa of *M. huttoni* Edw.
14. Diagram of spine arrangement of fifth abdominal segment of pupa of *M. atridorsum* Alex.

Prothorax rather long, its apical margin with a broad, median V-shaped emargination. Pronotal breathing-horns (fig. 8) elongate (length, 2-2.5 mm.), cylindrical, their bases widely separated; save at apices, the surface distinctly corrugated; apices rounded, smooth, divided into hemispheres by a shallow, terminal incision. Between the level of the pronotal breathing-horns and the cephalic margin, the pronotum bears two pairs of widely separated minute tubercles, their margins chitinized and minutely crenate.

Mesonotum slightly gibbous, smooth, without ornamentation. In some pupae the V-suture of the adult is slightly indicated. Wing-pads extending to the anterior end of the third abdominal segment. In older pupae a large, white stigmal area is conspicuous. The tarsal sheaths end at markedly different levels: prothoracic tarsi end opposite the posterior annulus of the 5th abdominal segment; mesothoracic tarsi end opposite the same region of the 6th segment; the slightly longer metathoracic tarsi end at anterior end of 7th segment. In specimens with curved abdomens the position of the tarsi relative to the abdominal segments may be shifted.

Abdominal segments 2 to 7 are divided into distinct basal and distal annuli. Ventrally the basal annuli are unarmed, the distal annuli bearing four acute, curved, chitinized points, a pair to either side of the tarsal sheaths. Dorsally the basal annuli are unarmed, the distal annuli with a transverse row of chitinized points at distal margins. These points range in number from 16 (segments 2 and 3) to 8 (segments 6 and 7). In pleural region basal annuli have a single, long, curved, chitinized point; distal annuli a group of three similar points. Segment 8 bears a circle of 6 large conical tubercles. chitinized toward apices. Cauda of female with sternal valves short, straight, hardly projecting beyond the rest of segment; tergal valves well dorsad of ventral, small, rounded, separated medially. Above dorsal lobes is a group of three conical tubercles.

Described from larvae taken from rotten log of *Eucalyptus globulus*, Govenor's Bay, New Zealand, Nov. 28, 1922, and from pupae reared from this lot of larvae by Mr. J. F. Tapley. Other lots of material of this species were from Governor's Bay and from Riccarton Bush, Christchurch.

### **Macromastix dichroithorax** Alexander.

#### *The Pupa* (Figs. 10 and 12).

Length, 15-16 mm.; diameters at base of wing-pads: dextro-sinistral, 2.5 mm.; dorso-ventral, 2.5 mm.; breadth of 5th abdominal segment, 3 mm. Form cylindrical, rather slender.

Colour (alcoholic specimens), an almost uniform chestnut-brown save for transverse bands of brownish yellow on the abdominal tergites and sternites, and the pleural region of the abdomen light brown.

Head with a prominent, bluntly conical cephalic tubercle; surface of this tubercle roughened with transverse chitinous ridges and bearing on latero-dorsal faces two pairs of very small secondary tubercles. Antennae arising from slightly dilated bases at ventro-laterad margins of cephalic tubercle and ending a short distance beyond bases of wing-pads. Cheeks with their ventro-laterad angles projecting. Labrum markedly convex, proximal margin abruptly elevated, with transverse wrinkles whose crests are chitinized. Labial sheaths elongate, mesal ends rounded, barely contiguous. Maxillary palpi tapering evenly to slender apices gently arcuated where they cross the knees of prothoracic legs, to end in contact with antennal sheaths.

Prothorax rather elongate dorsally. Cephalic margin with a deep U-shaped median notch and rounded lateral angles whose surfaces are slightly tumid. Pronotal breathing-horns yellowish, 0.9 mm. long, slender, cylindrical, somewhat constricted at bases; surfaces corrugated almost to tips which are faintly bisected.

Mesonotum with fine furrow-like, transverse ridges that are most marked on dorso-lateral angles of prescutellar region. Wing-pads reaching to caudal margin of 2nd abdominal segment. Tarsal sheaths ending opposite 5th abdominal segment: prothoracic at cephalic margin, mesothoracic opposite basal annulus, metathoracic opposite caudal margin of distal annulus. Metanotum narrowly ridged along cephalic margin.

Abdominal segments 2 to 7 divided into distinct basal and distal annuli, sub-equal in length. On dorsum the basal annuli are unarmed; distal annuli bearing at mid-length or slightly beyond, mid-length, a row of small, chitinized points that curve caudad. On segments 2 and 3 the points are 14 in number; on segment 4, 11; on segments 5 and 6, 10; on segment 7, 8. In pleural regions each basal annulus and distal annulus of segment 2, bears a single, large, chitinized point, curved caudad at mid-length, distal annuli of segments 3 to 7 bear two such points. The sternites have basal annuli and distal annuli 2 to 5 unarmed; distal annulus of segment 6 has a single curved point at either side of median line, and that of segment 7, a row of 4 such points, two on either side of median line. The lobes of segment 8 acute, tips chitinized, bases dilated. Cauda with lobes tipped with acuminate chitinous spines.

Described from a lot of 14 pupae labelled, "Canterbury, New Zealand."

### **Macromastix huttoni** Edwards.

#### *Pupa Skin* (Fig. 13).

Length, 14.6 mm.; diameters at base of wing-pads: dextro-sinistral, 2.9 mm.; dorso-ventral, 2.5 mm.; breadth of 5th abdominal segment, 3 mm. Form approximately terete. The "skin" with a yellowish-brown tinge, deepening to brown on coxae, labrum, mouth parts, and margins of sclerites.

Cephalic tubercle evident, although split longitudinally by the emergence of imago, its surface lined with minute transverse wrinkles; a pair of small, relatively smooth secondary tubercles on dorsal surface. Antennal bases angulate; tips of antennae, if in normal position, would extend to slightly below bases of wing-pads. Sheath of labrum somewhat tumid, the transverse lines of its surface faint. Cheeks with the caudo-lateral angles projecting. Labial lobes scarcely contiguous medially. Maxillary palpi conical, tapering to slender apices that curve caudo-laterad to about reach antennal sheaths.

Pronotal breathing-horns yellowish, 1.3 mm. long; flattened cylindrical, oval in cross-section; surfaces corrugated; tips shallowly cleft in their long diameter. Wing-pads ending slightly before caudal margin of 2nd abdominal segment. Tips of tarsal sheaths oppo-

site 4th abdominal segment: prothoracic opposite basal annulus, the nearly level meso- and metathoracic tarsi opposite distal annulus.

Abdominal segments 2 to 7 divided into distinct basal and distal annuli, the latter slightly less than twice length of the former. On dorsum, basal annuli unarmed; distal annuli with a row of from about 12 (segment 2) to 8 (segment 7) small, caudally curved, chitinized points at a little beyond mid-length. In pleural regions basal annuli have a single, slender, long, curved, chitinized point, very small on segment 2; distal annuli bear two such points. The sternites have basal annuli unarmed; distal annuli also unarmed save for a single small point in median line of segment 4, a similar but larger point on segment 5, a row of 7 points on segment 6, and a row of 6 larger points on segment 7. Segment 8 with the six lobes acutely pointed, their bases somewhat thickened. Lobes of cauda small, blunt, save for a pair of large, pointed dorso-median lobes and a smaller pointed lobe just laterad of each dorso-median lobe.

Described from a single pupa skin (female) labelled, "Hatched out Feb. 2, 1924, Ohakune, Wellington." (T. R. Harris).

### **Macromastix atridorsum Alexander.**

#### *Pupa Skin (Fig. 14).*

Length, 11.2 mm.; diameters at base of wing-pad: dextro-sinistral 2 mm.; dorso-ventral, 2 mm.; breadth of 5th abdominal segment, 1.7 mm. Form slightly conical, thickest at base of wing-pads, from there tapering slightly to caudal end. Colour of pupa skin dark brown.

Cephalic tubercle scarcely evident (this may be due to its being entirely split), smooth, without secondary tubercles. Antennae very short, not reaching the bases of the wing-pads. Caudo-lateral angles of the cheeks acutely projecting. Labrum very faintly sculptured, apparently little or not at all tumid. Maxillary sheaths similar to those of *M. huttoni* but shorter and more slender, scarcely reaching antennal sheaths.

Prothoracic breathing-horns brownish, 0.6 mm. long, surfaces corrugated. Wings extending to cephalic margin of 3rd abdominal segment. Tips of tarsi opposite distal annulus of segment 5; the prothoracic at cephalic margin of annulus, the almost even meso- and metathoracic tarsal tips at caudal end of annulus.

Abdominal segments 2 to 7 with distinct basal and distal annuli, the latter somewhat the longer. Dorsum with basal annuli unarmed; distal annuli with a transverse caudal row of from 14 (segment 2) to 8 (segment 7), minute, chitinized points. The pleural regions with basal annuli bearing a single, chitinized point; distal annuli with a group of one larger and two smaller points. The sternites with basal and distal annuli unarmed save that distal annulus of segment 7 bears a pair of widely-separated, curved points at about mid-length. The lobes of segment 8 acutely pointed, arcuated through 90 degrees. Cauda with lobes slender, tips acuminate, curved, chitinized.

Described from the pupa skins of two males. The pupae were taken from leaf mould by Mr. T. R. Harris, at Ohakune, Wellington. The imagos emerged October 20, 1924.

In addition to the larva and pupae described above, the collection contains several vials of unidentified larvae that belong, without doubt, to the genus *Macromastix*. Some of these are almost certainly *M. albistigma* Edw., the others belong to two unknown species. The larvae of three species and the pupae of four are, no doubt, insufficient to permit an attempt to characterize the immature stages of so extensive a genus as *Macromastix* or a comparison with the immature stages of *Tipula*, which are still most imperfectly known. Certainly the immature stages of *Macromastix* seem as close to those of *Tipula* as would be expected from a consideration of the imagos. The most striking, though not necessarily absolute, differences, judged from the present material, appear to be: The larvae of *Macromastix* with anal gills un-lobed, ring-like; the disproportionately large ventral lobes of the spiracular disk, with their tumid, fleshy caudo-ventral margins; the slight development of setae on the body segments; the much stouter, blunter body form, with a more marked tendency to subdivision of the body into annuli; and, possibly, the form of the hypopharynx. In these characters the two unknown larvae resemble *M. albistigma* Edw., as they do in the general structure of the head capsule, but they show a much more *Tipula* like form of antennae and mandibles than does *M. albistigma*. The known pupae of *Macromastix* appear to agree in showing the following differences from *Tipula*: The pronotal breathing-horns equal; a transversely sculptured cephalic tubercle; the surface of the labrum tending to be tumid and sculptured with transverse lines (slight in *M. atridorsum*); the maxillary palpi not recurved; lobes of the eighth abdominal segment six, tending to be grouped in threes toward the lateral sides of the segment; and the relatively small caudal lobes.

Judging from the specimens at hand, the separation of the larvae or pupae of the species of *Macromastix* will not be more difficult than the separation of imagos. The three larvae before me show distinct and absolute differences in body form, spiracular disk and especially in the form of the labrum, mentum, mandibles, antennae, and maxillae. In the pupae the ornamentation of the abdominal segments will easily separate the four species described, which also show distinct differences in size, shape, length of pronotal breathing-horns, antennae, wing-pads and tarsal sheaths, and in the shape of the labrum and cephalic tubercle.

## A Note on the Validity of the Proctotrypoid Genus *Tanyzonus* Marshall.

By E. S. GOURLAY,

First Assistant Entomologist, Cawthron Institute, Nelson.

[Read before the Nelson Philosophical Institute 27th July, 1927; received by  
Editor, 10th August, 1927; issued separately,  
8th November, 1927.]

THE Rev. T. A. Marshall (1892) described a Belytid from New Zealand under the name of *Tanyzonus bolitophilae*. He based his description on a male and a female specimen reared from the New Zealand glow-worm *Arachnocampa (Bolitophila) luminosa* Sk. which he received from Mr. G. V. Hudson, of Wellington. Later (1892) he wrote a short article stating that Cameron advised him of having described the same insect as *Betyla fulva* in 1889 rendering his (Marshall's) description invalid. In 1898 Cameron confirmed this opinion.

The most recent reference to *T. bolitophilae* and *B. fulva* is made by Brues (1922), in which he expresses doubt of their identity.

I am indebted to Mr. Hudson for the privilege of being able to examine a male and a female Belytid reared from the same batch of glow-worm larvae and identical with those sent to Marshall. It will be noticed that in Marshall's original description of *T. bolitophilae* he records that he did not examine the abdomen ventrally; and later, in admitting the synonymy with *B. fulva*, apparently still failed to examine his specimens for one outstanding generic character of *Betyla*, viz., the presence of a large tooth below the petiole.

Neither of Mr. Hudson's specimens has any trace of a tooth so situated, but as the other generic characters are so similar it is difficult to determine the identity of *T. bolitophilae* with certainty until Cameron's type is examined; as, however, the most careful examination of these specimens fails to reveal the essential characteristic of *Betyla*, it would appear that *T. bolitophilae* is a distinct insect.

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CAMERON, P., 1889. *Manchester Memoirs*, p. 13.  
— 1898. *Manchester Memoirs*, p. 41.  
MARSHALL, T. A., 1892. *Entomologist's Monthly Magazine*, pp. 275, 308.

## Description of Two New Species of Marine Gasteropod.

By C. E. R. BUCKNILL, L.M.S.S.A., Lond.

[Read before the Auckland Institute, November 9th, 1926; received by Editor, 22nd June, 1927; issued separately, 8th November, 1927.]

(Plate 35).

Family TURRITIDAE H. & A. Adams.

*Scrimum* Hedley 1922.

C. Hedley, "A Revision of the Australian Turridae." *Records of the Australian Museum*, vol. 13, No. 6, p. 258, 1922.

Shell small, oblong, rounded at each end, whorls few. Protoconch low, dome-shaped. Colour yellow and brown, uniform or variegated. No differentiation of fasciole area. Sculpture of obscure radial ribs and faint spiral grooves. Aperture rather wide, smooth within; sinus shallow, lip simple, canal short and wide, with an everted margin; columella concave and twisted.

Type. *Mitromorpha brazieri* Smith.

8 fath. Watson Bay (type).

"To *Scrimum* I would also refer *Bela neozelanica* Suter, from North N.Z." (C. Hedley).

*Scrimum sandersonae* n. sp. (fig. 1).

Shell small, fairly solid, fusiform, polished. Sculpture consisting of strong rounded axial ribs, about twice breadth of intercostal spaces, extending from suture to suture on spire-whorls; on body-whorl not so prominent, and become obsolete before reaching periphery; 15 ribs on body-whorl, 12 on penultimate whorl. Fine unequally spaced spiral striations everywhere present, though less conspicuous on outer curvature of ribs. Whorls 4 regularly increasing, very slightly angled, shoulders faintly concave, the dark colour stripe intensifying the turriculate appearance of spire. Base concave, a slight constriction at neck. Spire elevated, conic, a little higher than height of aperture. Protoconch flattened globose, of about one whorl, smooth; nucleus depressed. Suture lightly impressed and regular. Aperture oblique, rather widely ovate, channelled above and terminating below in short open canal. Outer lip blunt, regularly convex, with shallow sinus at shoulder; basal lip everted somewhat and bounded by thickened rounded edge. Inner lip narrow, defined by a more or less vertical furrow on outer side, and highly glazed. Columella slightly arcuate, subvertical. Colour uniformly pale fawn, deeper on base, with broad spiral stripe on shoulder, light brown on post-nuclear whorl and gradually deepening to dark brown, which further becomes a milky

tinge and finally fades off as it approaches aperture. *Operculum* and *animal* unknown.

Diameter, 6.5 mm. Height, 12.5 mm. Angle of spire  $40^{\circ}$ .

Holotype in Author's collection.

*Habitat*. Matauri Bay, Whangaroa.

*Remarks*: Mr. A. W. B. Powell, who kindly compared this species for me with other allied forms, writes to say that "*Scrinum neozelanica* Suter, is a differently-coloured shell from *sandersonae*, proportionately narrower and with axial costae not extending above the shoulder."

I have named this species in honour of Mrs. Sanderson of Totara North, Whangaroa, who discovered it, and to whom I am much indebted for this and many other specimens on previous occasions.

***Mayena multinodosa* n. sp. (fig. 2).**

*Shell* large, rather thin, nodulous, with discontinuous varices. *Sculpture* consisting of numerous fine riblets, becoming more pronounced and distant towards base; everywhere crossed by fine growth-lines; axial ribs lightly indicated upper whorls, about 9 between varices, and also 5 equidistant spiral ribs upon each whorl; strong tubercles present at points of decussation; axials, spirals, and tubercles all tend to become obsolete at periphery of body-whorl. Strong varices present on opposite sides of shell, crossing whorls somewhat obliquely. They are ornamented with 5 strong transverse cords with finer cords between. Each varix being attached at its upper end to whorl above, results in a perfect echeloned formation. *Whorls* 9 regularly convex, base excavated at neck. *Protoconch* one and a-half smooth whorls, nucleus depressed. *Aperture* oblique, roundly ovoid, channelled above, by a strong quadrate tooth on parietal wall, and uppermost tubercle on outer lip. *Outer lip* broad and rather thin, presenting well-marked longitudinal groove, traversed by smaller grooves—indentations of the external cords; inner margin denticulate throughout its whole length. *Inner lip* forming a thin plate below, thick in middle third, and above lost in thin callus. *Canal* of medium length, outer border smooth, inner border bearing six well-defined teeth. *Columella* a little oblique, arcuate. *Colour* light brown, spiral sculpture a shade darker.

Diameter, 83 mm. Height, 163 mm. Angle of spire  $40^{\circ}$ .

Holotype in Author's collection.

*Habitat*. Cavalli Island, near Whangaroa, in 25 fathoms.

This species (four specimens) was secured recently by Mr. Eric Sanderson of Totara North, in cray-fish pots set in rocky grounds. *Xenophalium royana* Iredale, a further addition to our New Zealand molluscan fauna, has also been taken in similar circumstances in the same locality, the shells in each instance being introduced into the traps by hermit-crabs, *Eupargurus novae zelandiae*.

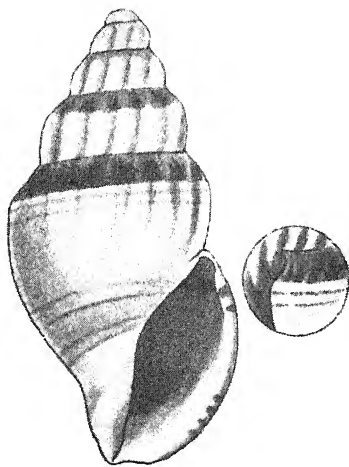


FIG. 1.—*Scrinum sandersonae* n. sp. Holotype, 12.5 mm.  $\times$  6.5 mm.

A. W. B. Powell del.

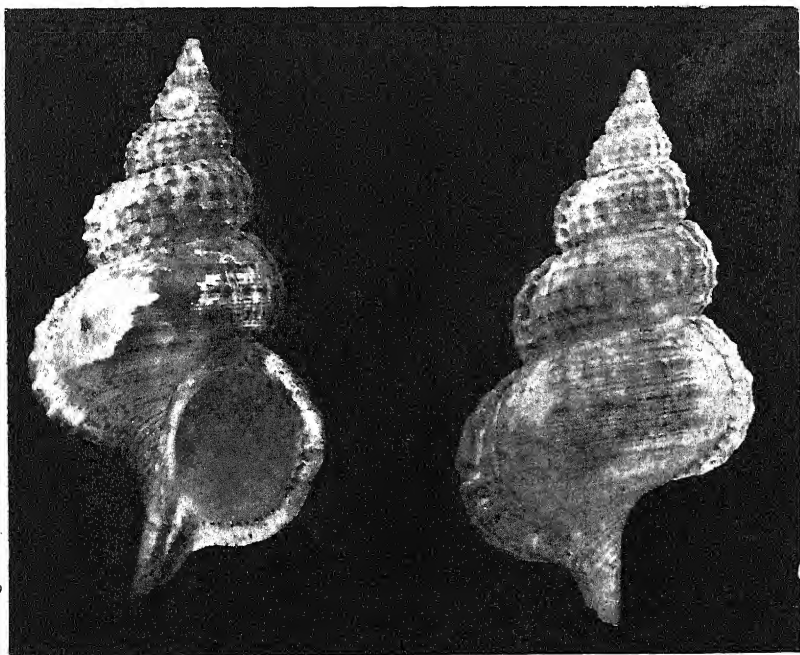


FIG. 2.—*Mayena multinodosa* n. sp. Holotype 163 mm.  $\times$  83 mm.



## Descriptions of New Zealand Lepidoptera.

By EDWARD MEYRICK, B.A., F.R.S.

[Read before the Wellington Philosophical Society, 7th September, 1927;  
received by Editor, 8th September, 1927; issued separately,  
12th November, 1927.]

I am once more indebted to the kindness of Mr. G. V. Hudson for the material of the following new species:—

### CARADRINIDAE.

#### *Aletia eucrossa* n. sp.

♀ 36 mm. Head, palpi, and thorax grey-whitish mixed fuscous. Forewings costa straight, termen somewhat obliquely rounded, waved; brownish-grey, basal two-fifths and a costal stripe suffusedly irrorated whitish, veins in disc suffused blackish-grey; sub-basal line indicated by two straight blackish strigulae from costa; small oblique black spots on costa at  $\frac{1}{3}$  and  $\frac{2}{3}$ , and a third between them; first and second lines curved, acute-dentate, whitish, edged black on veins, median shade obsolete; orbicular and reniform near together, edged whitish suffusion, orbicular round, reniform transverse-oblong, its lower edge whiter; terminal area sprinkled whitish; cilia brownish-grey mixed darker, sharply barred white. Hindwings grey, veins darker; cilia white towards base whitish-ochreous.

Waiuku, March (Phil. Shepherd, Waiuku School); 1 ex.

#### *Melanchra cyanopetra* n. sp.

♂ 36 mm., ♀ 40 mm. Head, palpi, and thorax dark bluish-grey. Antennae ♂ serrate, moderately fasciculate-ciliated. Abdomen grey. Forewings posteriorly dilated, termen bowed, rather oblique, waved; rather dark bluish-grey; first line posteriorly and second anteriorly edged by fine interrupted waved black lines or crescentic marks, second edged posteriorly by some black dots; median shade slender, indistinct, dark grey, irregularly dentate; orbicular and reniform of ground-colour, partially or hardly edged dark grey, orbicular round, reniform transverse, without white scales; claviform obsolete; subterminal line slender, faintly pale or slightly whitish-tinged, without perceptible teeth; cilia grey. Hindwings grey, somewhat darker terminally, veins darker; cilia grey, tips whitish.

Waiho Gorge, February, April; 2 ex. (Miss Castle.)

Nearest *M. omicron* Huds., with similarly-formed forewings (therefore less elongate than most New Zealand species of the genus), but distinguished by the peculiar bluish tinge, and absence of the small but well-marked claviform of that species.

### HYDRIOMENIDAE.

#### *Chloroclystis rufipellis* n. sp.

♂ 21 mm. Head, palpi, thorax brown-reddish. Antennae strongly fasciculate-ciliated. Abdomen brown-reddish, a dark fuscous

sub-basal band. Forewings rather elongate-triangular, termen oblique, slightly bowed, hardly waved; red-brown; a curved fascia of obscure pale striae towards base; median band moderate, oblique darker, infuscated, forming two darker costal spots at sides, preceded and followed by fasciae of obscure ochreous-whitish striae, anterior edge concave, posterior obtusely prominent in middle, slightly bisinuate on upper half; subterminal line fine, whitish, waved-dentate, forming a small distinct white dot above tornus, and traversing two cloudy dark grey spots before middle of termen connected with termen by dark bars: cilia reddish-grey, basal half obscurely barred dark grey. Hindwings rather narrow, termen irregular, rather deeply sinuate between 4 and 6 and broadly prominent from 3 to 4; brown-reddish, costal half greyish; a curved post median fascia of pale ochreous striae, preceded by dark grey towards dorsum; subterminal line as in forewings; cilia brown-reddish, obscurely barred grey.

Wellington, Gollan's Valley, bred in September from pupa found amongst moss (Hudson); 1 ex.

#### OECOPHORIDAE.

##### *Trachypepla cyphonias* n. sp.

♂ 15 mm. Head ochreous-whitish. Palpi ochreous-whitish, second joint dark fuscous except apex, terminal joint with two dark fuscous rings. Antennal ciliations 1. Thorax ochreous-whitish, shoulders fuscous. Forewings elongate, termen very obliquely rounded; purplish-fuscous, darker-sprinkled, costa suffused darker; an ochreous-whitish spot on base of dorsum; first discal stigma formed of black and white raised scales, plical small, of black raised scales, beneath first discal, second discal included in a curved transverse linear white mark edged with raised black scales; a minute whitish dot on costa before middle; a suffused whitish triangular dot on costa beyond  $\frac{2}{3}$ , whence a very indistinct irregular curved series of undefined dots of blackish irroration runs to tornus: cilia greyish, with series of ochreous-whitish points. Hindwings grey, paler near base; cilia ochreous-whitish, with faint pale greyish lines.

Wellington, December (Hudson); 1 ex. Quite distinct from anything else.

#### HYPONOMEUTIDAE.

##### *Zelleria porphyraula* n. sp.

♂ 13 mm. Head white, forehead and a lateral stripe on crown light fulvous, forehead sprinkled black. Palpi pale grey sprinkled black. Thorax dark bluish-grey, a central whitish streak, tegulae purple. Forewings narrow, costa arched towards pointed apex; bronzy-greyish-ochreous, slightly orange-tinged; costal edge greyish-purple, with some scattered small black dots; sub-costal and median suffused greyish-purple streaks, confluent towards base and terminating in an apical blotch, median interrupted by a whitish patch above tornus; suffused white dots on sub-costal representing discal stigmata and one on median obliquely before first discal representing plical; an irregular white streak above dorsum from near base to middle of

wing, sprinkled or dotted black, dorsum beneath this narrowly brownish-ochreous from base to tornus, dorsal edge towards base mottled black; a few white scales towards apex: cilia bronzy-brown, on tornal area light greyish, tips round apex black, at origin of costal cilia some white scales. Hindwings light bluish-grey; cilia light grey.

Wellington, April, beaten from *Podocarpus totara* (Hudson); 1 ex.

#### PLUTELLIDAE.

##### *Orthenches dictyarcha* n. sp.

♂ 19 mm. Head and thorax whitish-brownish, face with a whitish bar. Palpi brown, apex of joints white, terminal joint not longer than second. Forewings rather narrow, slightly dilated, termen straight, rather strongly oblique; 7 to termen; white, veins and transverse strigulae dark fuscous, forming an irregular reticulation; five sub-triangular dark fuscous spots on dorsum from  $\frac{1}{4}$  to  $\frac{3}{4}$ , plical area suffused pale bronzy-ochreous above these; three very irregular oblique fuscous fasciae partially suffused dark fuscous on edges from costa at one-fifth, two-fifths, and three-fifths, terminated by plical suffusion; two dark fuscous spots on costa posteriorly, and a prae-marginal streak before lower part of termen; cilia fuscous, a darker basal line, a white spot below apex, tornal area partly suffused whitish, costal cilia white barred dark fuscous. Hindwings 4—6 rather approximated towards base; pale grey; cilia grey-whitish.

Arthur's Pass, 3,000 feet, January (Hudson); 1 ex. The largest species of the genus.

#### LYONETIADAE.

In find that the genus *Hieroxestis* Meyr., hitherto distinguished from *Opogona* by the presence of rough hairs on crown behind the frontal fillet, is not tenable, passing insensibly into that genus both structurally and superficially. Therefore *omoscopa* Meyr., the type of *Hieroxestis* and an immigrant in New Zealand, and also *aureo-squamosa* Butl. from the Kermadecs, must be referred to *Opogona*. But the genus *Amphixystis* Meyr. must be revived for *hapsimacha*, on which it was founded. On examining the unique type of this species, I regret to find that my original description, made some 26 years ago, is very poor and unsatisfactory; the specimen was not in fresh condition, but admits of more adequate treatment, and I therefore now redescribe genus and species as under.

##### *Amphixystis* Meyr.

Head smooth, a raised frontal fillet, behind it a thin ridge of erect hairs, face very retreating; tongue obsolete. Antennae nearly 1, scape (basal joint) moderate, swollen, without pecten. Labial palpi moderate, slender, smooth, second joint curved, sub-ascending, terminal joint shorter, porrected, obtuse. Maxillary palpi long, several-jointed, folded, filiform. Posterior tibiae with long hairs above. Forewings with apex down-turned, 1 b simple, 2 from beyond  $\frac{3}{4}$ , 3 from  $\frac{5}{8}$ , 4 and 5 connate from angle, 6 and 7 stalked, 7 to costa, 8

almost connate with 6, 9 approximated, 10 from  $\frac{3}{4}$ , 11 from middle. Hindwings  $\frac{3}{4}$ , narrow-lanceolate, cilia 3; 2-4 remote, parallel, 5 and 6 connate from apex of cell, 7 closely approximated at base.

**A. hapsimacha** Meyr.

♀ 14 mm. Forewings greyish-ochreous, some scattered blackish scales on edges of markings; markings shining silvery-withish, viz., a slender costal streak from base to apex, confluent over central third with a broader supramedian streak from base to  $\frac{3}{4}$ , where it is terminated by an irregular transverse streak, a submedian streak from base to about  $\frac{3}{4}$ , and a dorsal line from base along termen to apex; a few blackish scales in a linear series in disc towards apex; cilia ochreous-whitish, on costa towards apex a blackish basal line. Hindwings brassy-grey; cilia greyish.

Wellington.

TINEIDAE.

**Tinea atmogramma** n. sp.

♂ ♀ 12 mm. Head grey, face ♀ whitish. Palpi white, externally dark grey except apex of joints. Antennae  $\frac{3}{4}$ , dark grey. Thorax blackish, tips of tegulae whitish, on each side of metathorax above a shining pellucid spot. Forewings elongate, apex pointed, termen very oblique; dark grey irregularly mixed and suffused black; an oblique obtusely angulated whitish stria near base, thick in ♀; three irregular angulated fasciae of two or three suffused white striae each, before and beyond middle and at  $\frac{4}{5}$ , slender and imperfectly marked in ♂, thicker and whiter in ♀, first forming an irregular white spot on dorsum, third forming a distinct white dot at tornus; several white dots on margin round apex: cilia grey, dark grey median and apical shades, in ♂ slight white dashes above and below middle of termen and beneath tornus, in ♀ suffused white median and tornal patches. Hindwings dark purplish-grey, an indistinct blackish-sub-basal shade.

Arthur's Pass, 3,000 feet, January (Hudson); 2 ex. Nearest *argodelta*, but does not show the clear white dorsal spot of that species, the antennae much shorter (remarkably short for the genus), and otherwise quite distinct.

## The Male Genitalia of the New Zealand Plutellidae.

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[Read before the Nelson Philosophical Society, 29th June, 1927;  
received by Editor, 10th June, 1927; issued separately,  
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### INTRODUCTORY.

THE Plutellidae are usually considered to form a fairly well characterized family, though Forbes (*The Lepidoptera of New York and Neighbouring States*. Cornell University Memoir, 68, p. 337, 1923) prefers to treat the group as a subfamily of the Hyponomeutidae. The New Zealand representatives are but a fragmentary assemblage, but a study of the male genitalia shows that, on the whole, they exhibit certain well defined characters in common, and it is possible that the few striking exceptions may not have been correctly referred to the family.

The New Zealand Plutellids comprise 27 species, placed in 9 genera. All but two of the genera are endemic and all but three of the species. The non-endemic species belong to the genus *Plutella*, two of which, *P. sera* Meyr. and *P. psammochroa* Meyr., also occur in Australia, the remaining one being the cosmopolitan *P. maculipennis* Curt., without doubt accidentally introduced.

Usually the modification of the parts relative to the reproductive function extends to the eighth segment, sometimes to the seventh. In most instances the eighth segment is divided dorsally and ventrally and forms a pair of lateral flaps, between which lie the genitalia proper. Such flaps are not to be confused with the "coremata" of Pierce (*The Genitalia of the British Geometridae*); they are not pouch-like, but the simple results, modified a little in shape, of the dorsal and ventral splitting of the segment. Another fairly general character is the presence of a pair of lateral hair sacs attached to the vinculum. A pencil of hairs, usually long, is set in a shallow membranous pocket, the brush lying horizontally to the plane of the body with the tips projecting beyond the apices of the harpes. Probably these pockets are evertible so that the hairs, when functioning, are spread out in a radiating bunch. The harpes are, for the most part, entire and rather weakly chitinized, the supporting parts of the eighth segment rendering heavy chitinization unnecessary. The gnathos may be present or absent, and in no case is there an elaborate juxta.

### *Plutella* Schrank.

A cosmopolitan genus, of which there are five species in New Zealand. Two of these, as noted above, are also found in Australia and one is the accidentally introduced world-wide pest, *P. maculipennis* Curt.

**P. maculipennis** Curt. (Fig. 1).

The tegumen is very small, consisting almost entirely of lateral pieces which bend round and embrace the anal tube, being partially fused at their apices beneath though free and forming a pair of small rounded lobes above. Vinculum fused with tegumen, moderate, with large saccus. Juxta a small plain folded plate. Aedeagus thin, rapier-like, entirely different from that of the other species. Harpes broad, entire, leaf-like, inner surface densely haired apically and with a small patch of stout, blunt erect spines near base; outwardly they bear, near the centre, a tuft of soft long hair. Hair sacs normal.

**P. psammochroa** Meyr. (Fig. 2).

Tegumen small, with small weak uncus and narrow lateral arms. Vinculum fused with tegumen, a strong caudal process and fairly long saccus. Gnathos a pair of thin processes with hairy apices, converging to meet on median line but not fusing; beneath these a flat quadrangular plate which is probably to be regarded as part of the gnathos. Aedeagus moderate in length, rather thin, apically dilated. Harpes large, entire, expanded apically, densely clothed within with weak hair on apical half. Hair sacs normal.

**P. sera** Meyr. (Fig. 3).

Tegumen weak, uncus absent. Vinculum fused with tegumen, narrow, with long thin saccus. Aedeagus long, moderately thick, cylindrical. Juxta absent. Harpes oblong, entire, inner surface thickly clothed on apical half with soft long hair and with a prominent central cone of shorter and coarser hair.

**P. megalynta** Meyr. (Fig. 4).

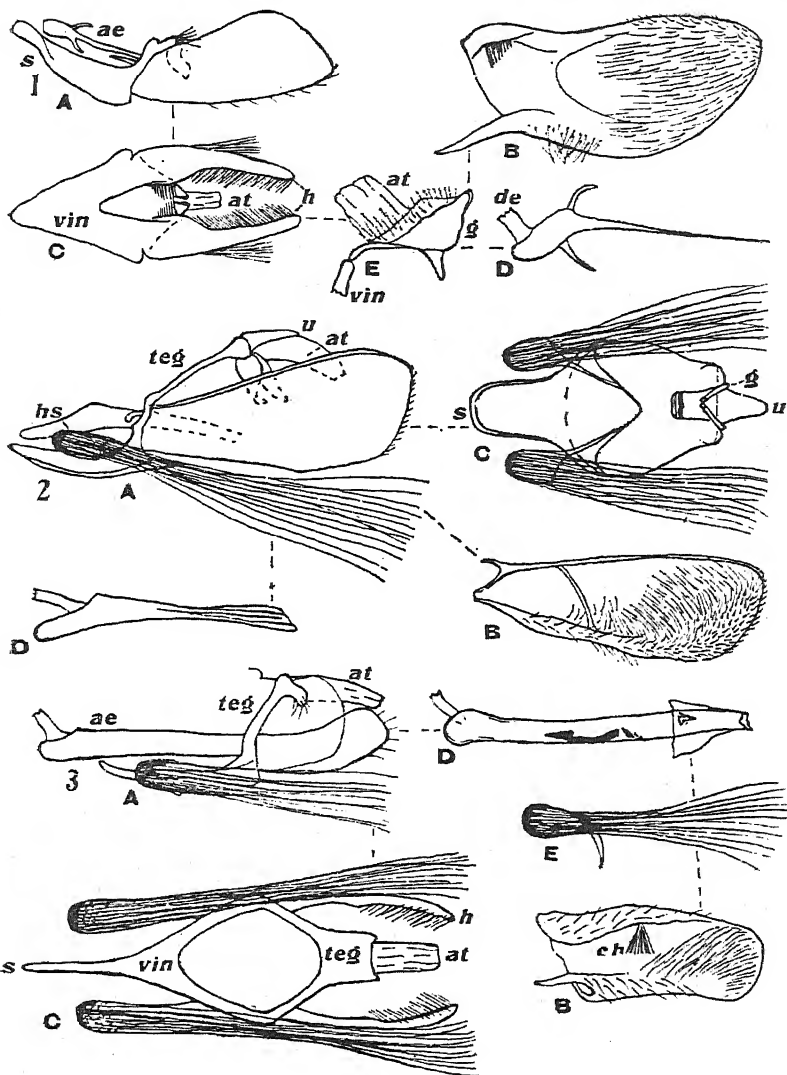
The male genitalia of *P. megalynta*—except for the eighth segment and the hair sacs, which are of the normal generic type—are very highly specialized. The tegumen, vinculum and harpes are solidly fused into a single strongly chitinated piece within which lies the large curved and sharply pointed aedeagus. On the dorsal line the part which I take to be the remains of the harpes is open down to the base, where the anal tube protrudes; on the ventral line there is complete fusion except at the apex, where there is a v-shaped cleft supporting the point of the aedeagus. No structures representing the gnathos or juxta can be made out, and the whole apparatus is a striking instance of specialization by reduction and fusion.

**Circoxena** Meyr.

Endemic and monotypic. The genitalia are highly specialized and depart widely from the ordinary Plutellid type.

**C. ditrocha** Meyr. (Fig. 5).

Genitalia very small. Tegumen broad, apex truncate, indented laterally just below apex. Gnathos a pair of clavate processes with rows of backwardly projecting barbules. Vinculum narrow, fused



LETTERING.

(ae, aedeagus; at, anal tube; c, colon; ch, central cone of hair on harpes of *Plutella sera*; de, ductus ejaculatorius; fs, fused genitalia of *Plutella megalynta*; g, gnathos; h, harpe; hs, hair sac; j, juxta; ps, paddle-shaped scales on tegumen of *Orthenches porphyritis*; s, saccus; sg, surgonopod; teg, tegumen; u, uncus; vin, vinculum; 7, seventh segment; 8, eighth segment.)

FIG. 1.—*Plutella maculipennis* Curt. A, male genitalia, lateral view. B, harpe, inner view. C, genitalia, ventral view. D, aedeagus. E, tegumen, lateral view.

FIG. 2.—*P. psammochroa* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, vinculum and tegumen, caudal view. D, aedeagus.

FIG. 3.—*P. sera* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, tegumen and vinculum, dorsal view. D, aedeagus. E, hair sac.

with tegumen, lateral arms strongly angled, saccus small. Aedeagus hardly chitinized, irregular, surrounded by a hood-like membranous structure with a chitinous apex, possibly the modified manica. Harpes simple, entire, leaf-like.

### **Orthenches** Meyr.

The dominant Plutellid genus in New Zealand, containing twelve species. A few others are to be found in Australia and India. Unfortunately, material of only four species has been available for dissection, the greater number being rare and poorly represented in collections. In the four forms referred to surprising differences manifest themselves for members of the same genus. The hair sacs are absent in all the species dealt with.

#### **O. glypharcha** Meyr. (Fig. 6).

All the organs are weakly chitinized. Tegumen fused with vinculum, forming a weak ring, slightly expanded dorsally where it is clothed with long hair; saccus moderately narrow. Anal tube extending far beyond tegumen, half hidden in long hair. Gnathos absent. Aedeagus moderate, thrust well beyond harpes, anellus with dense hair on median portion directed obliquely backwards. Harpes weakly chitinized, entire, deeply concave, especially towards base; a finger-like process on upper basal angle.

#### **O. similis** Philp. (Fig. 7).

Genitalia asymmetrical in harpes and vinculum. Tegumen fused with vinculum, uncus consisting of a pair of thin processes at dorso-lateral angles of tegumen, their apices being angled downwards. Gnathos a pair of finger-like processes, bent downwards but with the apices recurved and bearing a tuft of long hair. Vinculum with lateral arms narrow; saccus a large asymmetrical pointed concave plate. Aedeagus moderate, swollen basally. Harpes narrow, entire, the pointed processes from upper basal angles asymmetrical (see figs.).

#### **O. saleuta** Meyr. (Fig. 8).

Tegumen very small and weak, fused with broad U-shaped vinculum; saccus moderate. Anal tube projecting far beyond apex of tegumen. Gnathos absent, but probably indicated by a pair of slight processes carrying a few hairs. Aedeagus long, moderately stout, projecting beyond harpes. Harpes cleft into two widely-diverging prongs, upper basal angles produced into long thin structures which project dorsally past aedeagus and are then rectangularly bent caudally, the apices resting between the paired cuculli.

#### **O. porphyritis** Meyr. (Fig. 9).

The eighth segment is split on the ventral line only, the dorsal line having but a small indentation. Tegumen weak and narrow, dorsal part armed with long paddle-shaped scales. Anal tube long

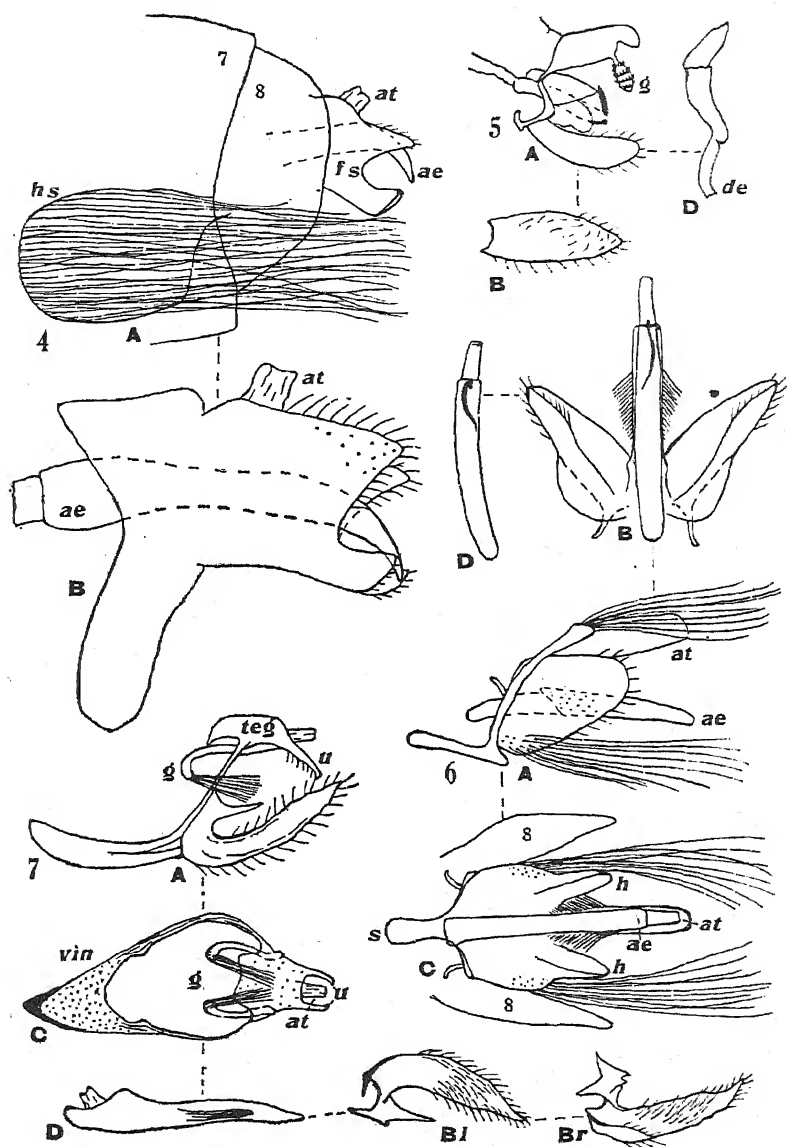


FIG. 4.—*P. megalyntha* Meyr. A, male genitalia, lateral view. B, genitalia, lateral view, eighth segment removed.  
 FIG. 5.—*Circorena ditrocha* Meyr. A, male genitalia, lateral view. B, harpe, inner view. D, aedeagus.  
 FIG. 6.—*Orthenches glypharcha* Meyr. A, male genitalia, lateral view. B, harpe, and aedeagus, dorsal view. C, genitalia, ventral view. D, aedeagus.  
 FIG. 7.—*O. similis* Philp. A, male genitalia, lateral view. Bl, left harpe. Br, right harpe. C, tegumen and vinculum, dorsal view. D, aedeagus.

and firm, projecting well beyond the genitalia. Vinculum fused with tegumen, narrow, and with moderately-long and narrow saccus. Aedeagus moderately long and stout, apically hairy and with a pair of short strong curved spines directed ventrally. Juxta absent. Harpes broad, entire, a two-pronged projection from upper basal angle, a brush of long hairs from lower basal angle without and clothed within on apical half with short stout scales.

### **Cadmogenes** Meyr.

Endemic and monotypic. Specimens of *C. literata* Meyr. have not been available for examination.

### **Phylacodes** Meyr.

Endemic and monotypic. The genitalia exhibit close affinity to *Protosynaema*.

#### **P. cauta** Meyr. (Fig. 10).

Tegumen with broad rounded uncus and large pointed surgonopods. Gnathos a pair of large clavate structures, flat within and with an armature of backwardly projecting barbules. Vinculum narrow, fused with tegumen, saccus long and thin. Aedeagus large, cylindrical. Harpes simple, entire, weakly chitinized and with feeble short hairs.

### **Protosynaema** Meyr.

A small endemic genus of three species, the genitalia of which agree well in main features.

#### **P. steropucha** Meyr. (Fig. 12).

Tegumen with moderate uncus, which is apically truncate, and small surgonopods. Vinculum fused with tegumen, narrow, with moderately long and narrow saccus. Gnathos a pair of conical processes, flat within and densely covered on apical half with short basally-directed barbules. Aedeagus stout with short ventral projection near apex. Juxta absent. Harpes rather narrow, regularly curved, entire, with short coiled process on upper basal angle.

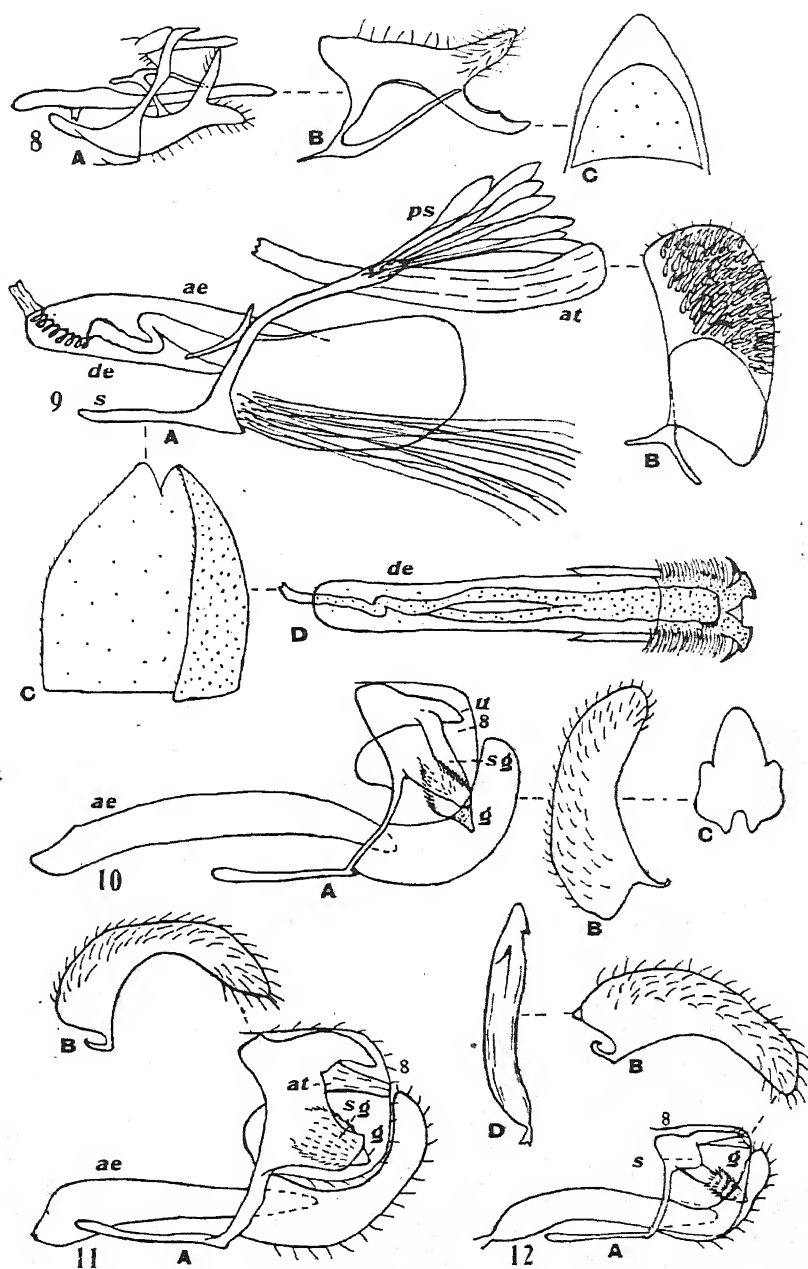
FIG. 8.—*O. saleuta* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, vinculum.

FIG. 9.—*O. porphyritis* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, eighth segment, obliquely ventral view. D, aedeagus.

FIG. 10.—*Phylacodes cauta* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, tegumen and uncus, dorsal view.

FIG. 11.—*Protosynaema quaestuosa* Meyr. A, male genitalia, lateral view. B, harpe, inner view.

FIG. 12.—*P. steropucha* Meyr. A, male genitalia, inner view. B, harpe, inner view. D, aedeagus.



FIGS. 8—12

**P. quaestuosa** Meyr. (Fig. 11).

Tegumen with moderate rounded uncus and large quadrangular surgonopods. Vinculum fused with uncus, narrow, saccus similar to *P. steropucha* but shorter and less pointed. Aedeagus moderate, swollen basally. Juxta absent. Harpes entire, like *P. steropucha* but narrower and more strongly curved.

**P. eratopis** Meyr. (Fig. 13).

Tegumen moderate with short rounded uncus and extended base. Vinculum fused with tegumen, narrow, saccus moderately long and thin. Gnathos longer and more pointed than in the other species. Aedeagus large, with ventral projection near apex. Harpes broad, entire, little curved.

**Doxophyrtis** Meyr.

Endemic and monotypic. The genitalia are highly specialized and reduced, recalling those of *Plutella megalynta* though there are great differences in detail.

**D. hydrocosma** Meyr. (Fig. 14).

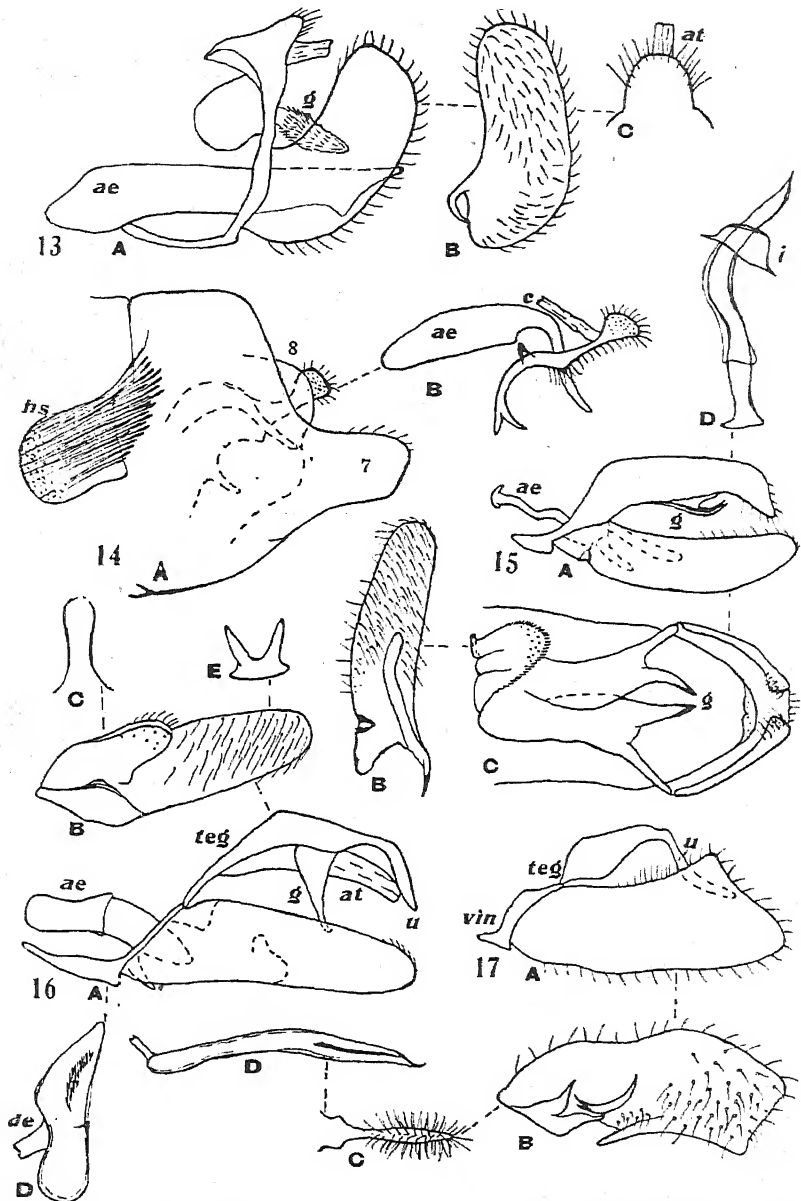
The genitalia are almost completely hidden within the eighth segment which is in turn withdrawn into the seventh. The seventh sternite projects much beyond the rest of the body but is cleft deeply on the ventral line so as to form a pair of flaps. The eighth segment also takes the usual form of lateral flaps but they are of small size. Tegumen and vinculum narrow, fused, but open both dorsally and ventrally, thus forming two lateral bands which are only slightly concave, just enough to allow of the aedeagus passing through. The vinculum is cleft into two prongs ventrally and near its junction with the tegumen each arm has a small rounded process engaging another on the aedeagus. The apices of the tegumen are dilated and hairy, the hairy area extending to the median line. The anus is situated between the dilated apices. Aedeagus with lower half stout, upper half much thinner and rectangularly bent. Harpes absent. Hair sacs large but hairs short and somewhat clavate. It is possible that what is here regarded as the tegumen and vinculum is really the much modified harpes, the ninth segment having completely disappeared. The relation of the parts to the aedeagus and the hairiness of the upper portion gives some support to this view, but there is no definite evidence on either side.

**Dolichernis** Meyr.

Endemic. Contains two species, widely differing in genitalic characters.

**D. chloroleuca** Meyr. (Fig. 15).

Tegumen large, fused with small vinculum. Gnathos elaborate, tongue-like, a pair of curved prongs directed caudally and the body



- FIG. 13.—*P. eratopis* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, uncus, dorsal view.
- FIG. 14.—*Doxophyrtis hydrocosma* Meyr. A, male genitalia, lateral view. B, genitalia, lateral view, eighth segment removed. C, uncus, dorsal view.
- FIG. 15.—*Dolichernis chloroteuca* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, tegumen, ventral view. D, aedeagus.
- FIG. 16.—*D. jubata* Philp. A, male genitalia, lateral view. B, harpe, inner view. C, uncus, dorsal view. D, aedeagus. E, juxta.
- FIG. 17.—*Thambotricha vates* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, uncus, dorsal view. D, aedeagus.

of the organ sweeping in the opposite direction to end in a broad recurved plate between the harpes. Aedeagus short, sinuate, bent. Juxta a plain cap-like structure embracing the aedeagus. Harpes long, narrow, entire, with long finger-like lobe arising from upper basal angle within.

**D. jubata** Philp. (Fig. 16).

Tegumen narrow with moderately long angled spatulate uncus. Vinculum imperfectly fused with tegumen, with thin arms and moderate saccus. Gnathos without armature, forming a plain ring upturned at apex. Aedeagus short and thick. Harpes large, weak, entire, with a broad flap on lower margin within at about half and a fold on upper basal angle. Between the bases is a pair of short horn-like lobes; these are fused with the harpes but appear to be the modified juxta.

**Thambotricha** Meyr.

Endemic and monotypic. The genitalia are simple but depart widely from the Plutellid type.

**T. vates** Meyr. (Fig. 17).

The eighth segment is not modified. Tegumen not fused with vinculum, uncus long and hairy. Vinculum very small with slight saccus. Gnathos absent. Aedeagus thin, acutely pointed. Harpes broad, sharply angled at upper apical corner, entire, several irregular processes or folds within towards base.

## The Male Genitalia of the New Zealand Lyonetiidae.

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by Editor, 10th July, 1927; issued separately,  
8th November, 1927.]

MODERN systematists are not in agreement as to the rank of the group of Lepidoptera here dealt with. For instance, Meyrick (4), Comstock (1), and Forbes (2) treat it as a family; Tillyard (7) reduces it to subfamily rank, while Imms (3) would apparently follow the earlier opinion of Meyrick and not recognize even subfamily status. For the purpose of the present paper, however, the exact systematic value of the group is of little importance. The New Zealand genera are too few and too little representative to base conclusions of much value upon, even on a survey of the whole of the characters, while in the case of the male genitalia a confusing position arises from the extraordinary generic differences present, some groups having the parts of ordinary structure and simplicity while others exhibit the most intricate complexity, a complexity made still more difficult of comprehension by the absence of symmetry.

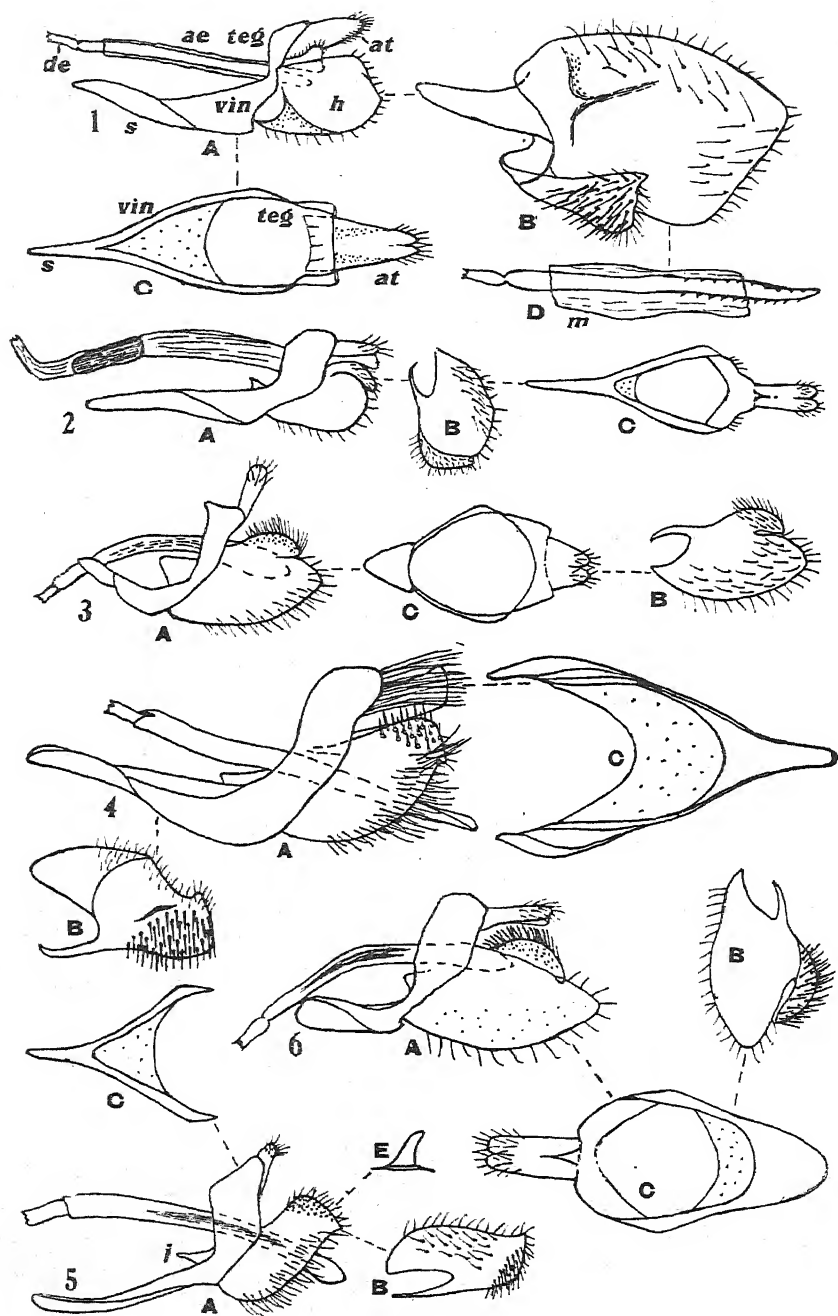
In this connection, however, the writer would suggest that one at least of the most specialized genera, i.e. *Dryadaula*, belongs to the Tineidae proper, the genitalia characters pointing to a close affinity with *Sagephora*. In creating the genus *Dryadaula* Meyrick (5) followed this course but in more recent work he has assigned the genus to the Lyonetiidae.

The Lyonetiidae are represented in New Zealand by 30 species—only 18 of which have been available for examination. Of these 30 species, one, *Bedellia somnulentella* Z., is a cosmopolitan form, while three others, *Cateristis eustyla* Meyr., *Opogona comptella* Walk., and *Hieroxestis amoscopa* Meyr. are common to Australia and New Zealand. The species studied below fall into two well defined sections, those with simple genitalia and those in which the organs are highly specialized. The former group will be considered first.

### **Erechthias** (Figs. 1 to 6).

Eleven New Zealand species have been described. Though the genus is well represented in Australia all the New Zealand forms are endemic.

Tegumen fused with vinculum but area of fusion not strongly chitinated. A true uncus is not present, but the anal tube, which extends some distance beyond the tegumen, is protected dorsally, and to some extent laterally, by a membranous shield, which is usually divided into two small lobes apically. A few short hairs clothe these lobes and there are generally lateral fringes of rather long hairs. This description applies to most of the genera at present under consideration. In most species the vinculum has a rather long and narrow saccus but in *E. fulguritella* Walk. and *E. macrozyga* Meyr. it



FIGS. 1-6.

is shorter and broader. Harpes broad, leaf-like, usually with curved densely spined costal lobe, which may be variously situated from apex to base. Juxta a plain folded triangular plate. Aedeagus thin, fairly long, slightly curved, sometimes with apical longitudinal series of small barbs.

The genitalia of this and the following genus closely approach the simpler types of the Tineidae, e.g., *Prothinodes*.

### **Hectacma** (Figs. 7 to 9).

A small endemic genus of five species.

The three species examined were found to be very consistent in genitalia characters, differing from each other in minor details only. The general plan closely follows that of *Erechthias*, but the vinculum is shorter and broader, the juxta more rounded and the aedeagus shorter and more strongly curved.

### **Bedellia** (Fig. 10).

Of this small but widely spread genus there are two species on the New Zealand list, one being endemic and the other, *B. somnulentella* Z., accidentally introduced. Only the latter species has been available for dissection.

Tegumen narrow, weak, fused with vinculum, which is broad, deep and strongly chitinated. Attached to the distal margins of the vinculum is a pair of membranous flaps bearing a dense tuft of long hair-scales which project caudally considerably beyond the large harpes. Harpes long, broad, obliquely truncate on lower apical angle. Aedeagus moderate, thin.

### **Opogona** (Fig. 11).

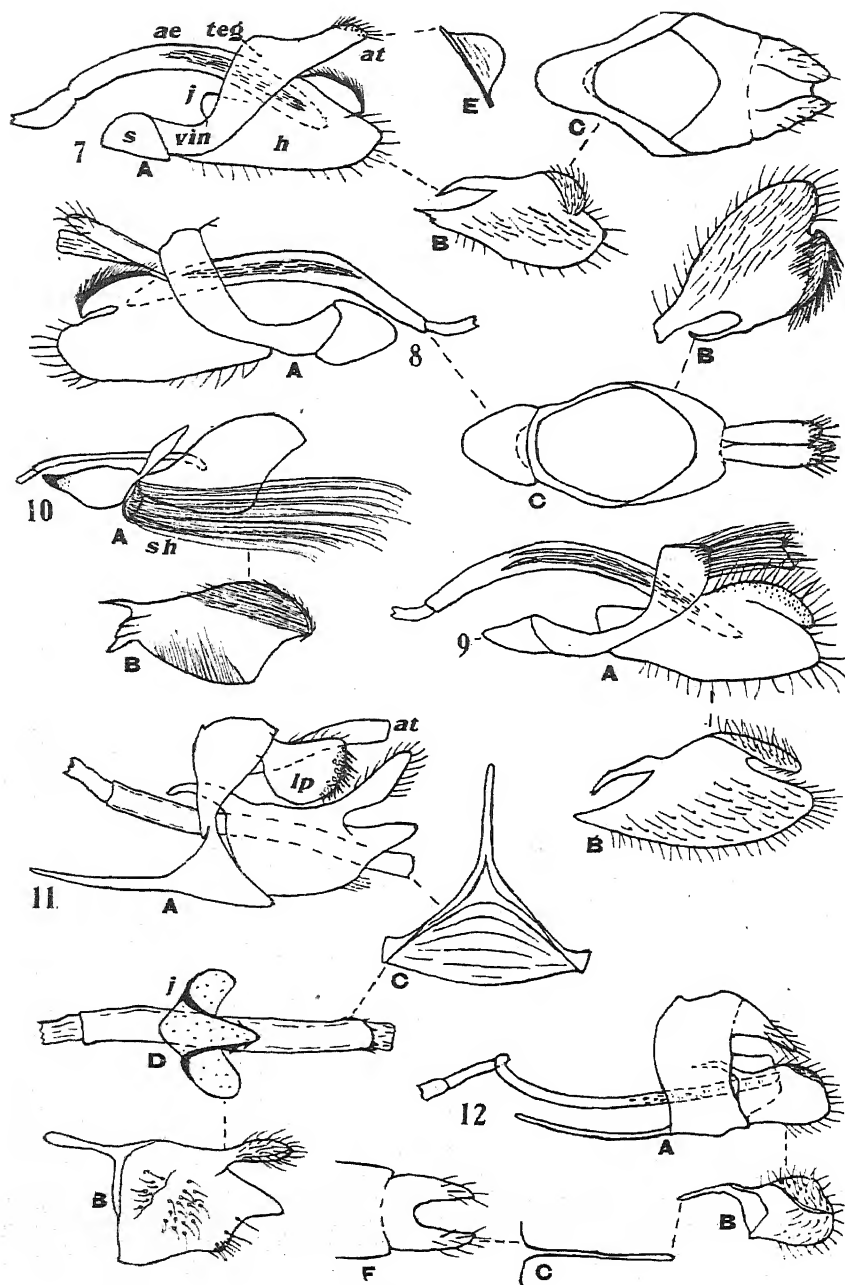
No endemic members of this genus have been found in New Zealand. The Australian *O. comptella* Walk. has been accidentally introduced.

Tegumen like that of *Hieroxestis omoscopa* Meyr. (see below), except that the uncus region is strongly emarginate. A similar pair of lateral flaps project distally but they are more firmly and broadly attached basally. They are not continuous with the margin but rise

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(Lettering: a, anus; ae, aedeagus; ap, apical plates of tegumen; at, anal tube; c, colon; de, ductus ejaculatorius; h, harpe; j, juxta; lh, left harpe; lp, lateral process of tegumen; m, manica; mc, membranous curtain beneath anal tube; rh, right harpe; s, saccus; sh, brush of sensory hairs beyond vinculum; teg, tegumen; u, uncus; vin, vinculum.)

- FIG. 1.—*Erechthias hemichlistra* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, tegumen and vinculum. D, aedeagus.  
 FIG. 2.—*E. externella* Walk. A, male genitalia, lateral view. B, harpe, from within. C, tegumen and vinculum.  
 FIG. 3.—*Erechthias macrozyga* Meyr. A, male genitalia, lateral view. B, harpe, from within. C, tegumen and vinculum.  
 FIG. 4.—*E. acrodina* Meyr. A, male genitalia, lateral view. B, harpe, from within. C, vinculum.  
 FIG. 5.—*E. charadrotia* Meyr. A, male genitalia, lateral view. B, harpe, inner view. C, vinculum. E, juxta.  
 FIG. 6.—*E. fulguritella* Walk. A, male genitalia, lateral view. B, harpe, inner view. C, tegumen and vinculum.



FIGS. 7-12.

from just within it, that is to say, from the position of the normal gnathos, with which organ they may be homologous. Vinculum fused with tegumen but junction very apparent. Harpes broad, divided into sacculus and cucullus of about equal length. Aedeagus moderate, fairly stout, apically barbed. Juxta closely embracing aedeagus, a cone with a few apical barbs and a pair of rounded lateral pieces.

### **Hieroxestis** (Figs. 12 and 13).

Two species are found in New Zealand, one, *H. hapsimacha* Meyr., being endemic, and the other, *H. omoscopa* Meyr., being found in Africa and also in Australia, from which latter country it has probably been introduced into New Zealand. The genitalia are so entirely different that it becomes necessary to describe each species separately.

**H. omoscopa** Meyr. Tegumen with short broad uncus, fused with vinculum but greatly constricted at point of union. On the dorso-lateral area are a pair of large, somewhat rounded chitinous flaps, their distal margins beneath being armed with several rows of short thick spines. These flaps are only chitinously connected with the tegumen narrowly at their upper angles, but have slight membranous attachment at their lower corners; the structures are very freely moveable. In all probability these organs fulfil the functions of surgonopods, but it is doubtful if they can be regarded as homologues of such structures, which are direct outgrowths of the lateral distal margins of the tegumen. The saccus is short and very broad, though appearing to be less broad than it is owing to the curving of its margins. Aedeagus short, thin, pointed. Harpes with short sacculus a long cucullus. Beneath the anal tube there is a membranous curtain or semisheath, tending to become more chitinous on the meson.

**H. hapsimacha** Meyr. Tegumen with deeply bifid uncus, very broad and passing into equally broad vinculum without constriction; saccus very long and thin. Aedeagus very long and thin. Juxta a plain folded plate. Harpes without cleft, short and broad.

It will be noted that there is hardly a feature in common between the foregoing two species of *Hieroxestis*. In describing *hapsimacha* Meyrick (6), erected for its reception the genus *Amphixystis*, but he afterwards treated this new genus as a synonym of *Hieroxestis*. In

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- FIG. 7.—*Hectacma chionodira* Meyr. A, male genitalia. B, harpe, inner view. C, tegumen and vinculum. E, juxta.
- FIG. 8.—*H. stilbella* Dbld. A, male genitalia, lateral view. B, harpe, from within. C, tegumen and vinculum.
- FIG. 9.—*H. chasmatis* Meyr. A, male genitalia, lateral view. B, harpe, from within.
- FIG. 10.—*Bedellia somnulentella* Z. A, male genitalia, lateral view. B, harpe, from within.
- FIG. 11.—*Opogona comptella* Walk. A, male genitalia, lateral view. B, harpe, from within. C, vinculum. D, aedeagus and juxta.
- FIG. 12.—*Hieroxestis hapsimacha* Meyr. A, male genitalia, lateral view. B, harpe, from within. C, saccus. F, uncus.

view of the general dissimilarity in the male genitalia it becomes a question whether the discarded genus should not be restored. As however, I am unacquainted with the other species of *Hieroxestis* I do not here propose to make any change.

### **Eschatotypa** (Figs. 14 and 15).

An endemic genus containing two species.

The genitalia are very complicated and difficult to understand. The two species differ in details but the general structure is much the same. The seventh and eighth segments are modified and must therefore be taken into account. The seventh sternite is slightly asymmetrical and has the posterior margin deeply and widely indented. The eighth tergite is long and is sharply bent downwards at about one half, the effect being to make it scoop-shaped. Within these sclerites, but not wholly covered by them, lie the eighth sternite and the genitalia proper. The tegumen is extraordinarily modified, no part answering to uncus or gnathos being present, and the lateral arms, which are directed very obliquely basad, bear a complicated series of stays or bands. On the dorso-lateral areas are a pair of spine-covered plates; possibly these may function in some degree as harpes, there being no trace of these latter organs. The vinculum is represented by a pair of smooth weak quadrangular plates, fused to the apical portion of the lateral arms of the tegumen and directed more or less obliquely towards the meson. The eighth sternite is strongly chitimized and appears to take up the position and function ordinarily assumed by the vinculum. Its distal end is broadly expanded and provided with various asymmetrical protuberances, while basally it is divided into two long arms which are attached at their extremities to the arms of the tegumen. It projects beyond the other parts of the genitalia, taking up the normal position of the harpes. Lying within the arms of the tegumen are the anal tube and the aedeagus, the latter being a strongly curved thin spring-like structure having associated with it certain parts which may represent the much modified juxta and anellus. In *E. melichrysa* Meyr. the aedeagus, though following the same general semicircular curve as in *E. derogatella* Walk., is curiously bent at several points. The association of the colon with the aedeagus is quite unusual, its almost invariable position being beneath the dorsal area of the tegumen.

It is interesting to note, in view of the total absence of the harpes in the male, that the seventh segment in the female, within which the eighth and ninth are normally withdrawn, has the sternite divided into two harpe-like lobes. It is possible that these structures may, in some degree, act as substitutes for the harpes of the male.

### **Eugennaea** (Fig. 16).

The genitalia of this monotypic endemic genus are asymmetrical and highly specialized. When in a normal position they occupy about half of the abdomen, extending back into the fifth segment. Owing to their extreme modification it is with difficulty that the various parts can be made out. The tegumen is asymmetrical; at its

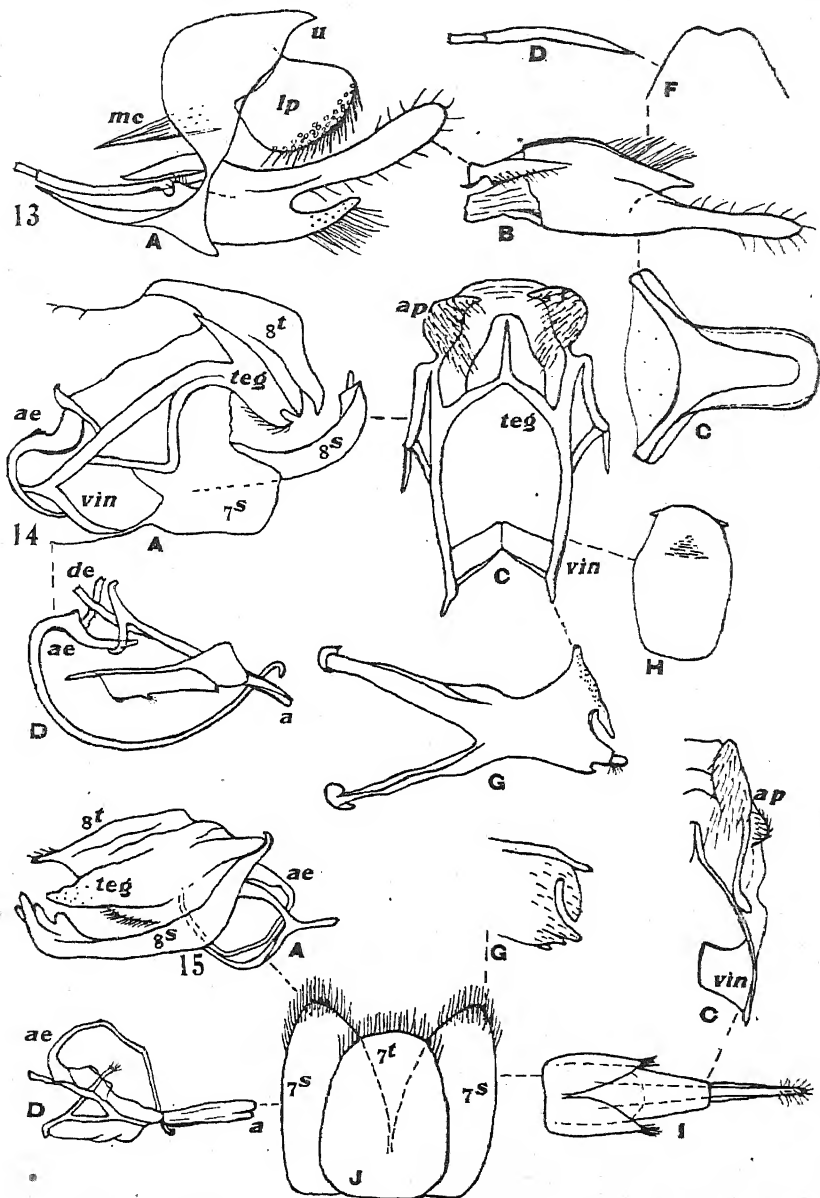
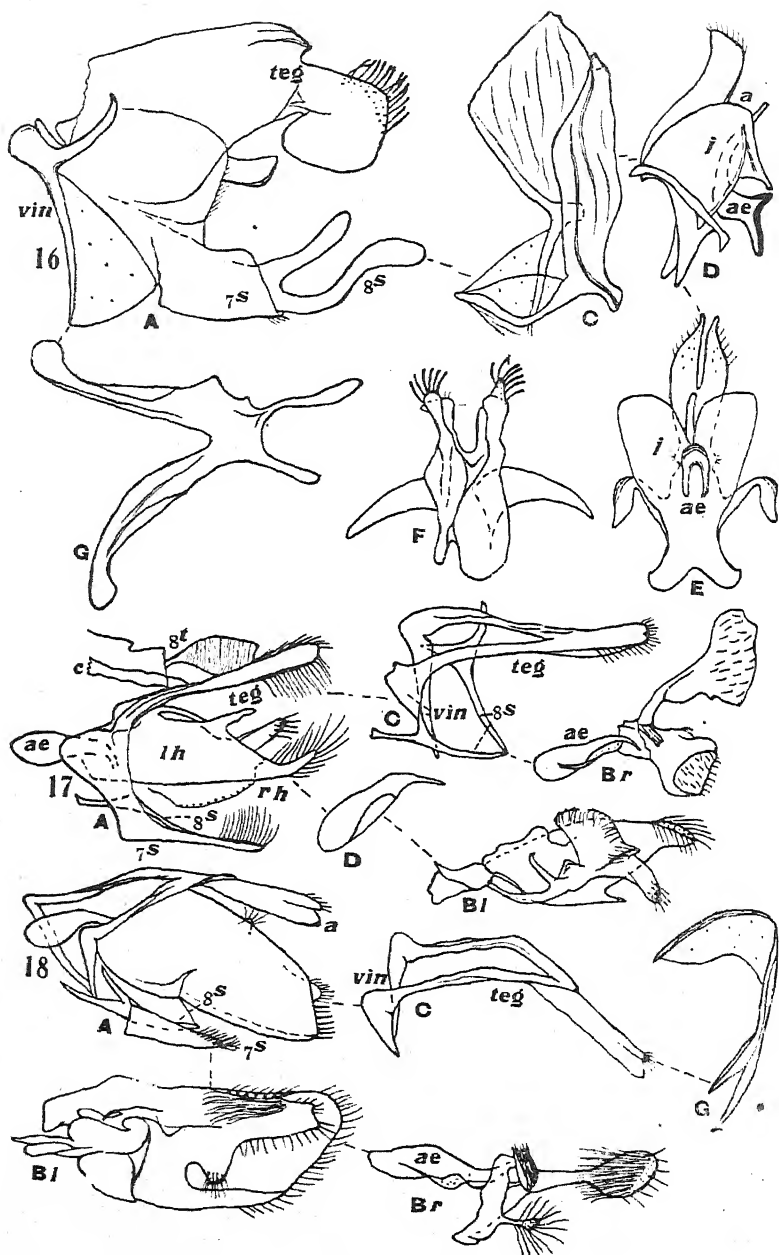


FIG. 13.—*H. omoscapa* Meyr. A, male genitalia, lateral view. B, harpe, from within. C, vinculum. D, aedeagus. F, uncus.

FIG. 14.—*Eschatotypa derogatella* Walk. A, male genitalia, lateral view. C, tegumen and vinculum. D, aedeagus and attachments. G, eighth sternite. H, eighth tergite.

FIG. 15.—*E. melichrysa* Meyr. A, male genitalia, lateral view. C, tegumen and vinculum, right half. D, aedeagus and attachments. G, eighth sternite, apical portion. I, seventh segment of female with ovipositor extruded. J, seventh segment of female, enlarged.



FIGS. 16—18.

broad apex there are a pair of irregular quadrangular plates, margined dorsally and caudally with rather long narrow scales. Behind these plates is another pair, curved and pointed, and directed rectangularly outwards. The lateral arms of the tegumen are broad and fuse with the vinculum at a sharp angle, the arms of the latter bending in to meet on the meson, from which point to each angle there stretches a smooth sheet of stiff membrane, an arrangement somewhat similar to that in *Eschatotypa*. The eighth sternite forms an irregular strongly chitinized sclerite, consisting mainly of two basal and two apical prongs, both pairs being quite asymmetrical. The aedeagus and its attachments consist of a short and stout structure occupying a median basal position in relation to the rest of the genitalia. The aedeagus itself is short and strongly curved, its base being bifid. The juxta is relatively large and has two broad lateral flaps and a broad excised basal portion. Above the aedeagus is a chitinous plate which expands into a strongly bifid leaf-like structure apically, while basally it divides into two arms which are sharply angled downwards and embrace the whole organ laterally. The anal opening is above the apex of the aedeagus at the base of the leaf-like part noted above, a structural peculiarity shared with the preceding genus. No trace of the harpes is to be found, though possibly some of the parts surrounding the aedeagus may be the highly modified remains of these organs.

### **Dryadaula (Figs. 17 and 18).**

A small genus confined to Australia and New Zealand. The three New Zealand species are endemic.

It has been pointed out above that the genitalia characters of *Dryadaula* closely approach those of *Sagephora* (Tineidae). There seems to be little doubt that there is a real and close relationship between the two genera though they have been hitherto frequently placed in different families. The various organs connected with the genitalia in *Dryadaula* are extraordinarily modified, such modification extending to the sixth and seventh segments, which are reduced and of weak chitination. There is no true uncus and the anal tube, which projects far beyond the margin of the tegumen, is in a measure protected as described under *Erechthias*. The tegumen consists of a narrow band and is fused with the vinculum, which is also narrow; the point of union is marked by a sharp angle. Embracing the vinculum is another narrow and asymmetrical band of chitin with the left apex divided into two prongs (in *D. myrrhina* Meyr.

FIG. 16.—*Eugennaea laquearia* Meyr. A, male genitalia, lateral view. C, tegumen (apical portion removed) and vinculum. D, aedeagus and attachments, lateral view. E, juxta and aedeagus. F, apical part of tegumen. G, eighth sternite.

FIG. 17.—*Dryadaula myrrhina* Meyr. A, male genitalia, lateral view. Bl, left harpe, from within. Br, right harpe and aedeagus. C, tegumen, vinculum and eighth sternite, obliquely lateral view. D, aedeagus.

FIG. 18.—*D. pactolia* Meyr. A, male genitalia, lateral view. Bl, left harpe, from within. Br, right harpe, and aedeagus. C, tegumen and vinculum, obliquely lateral view. G, eighth sternite.

both apices are pronged); this is the modified eighth sternite. The left harpe, viewed from without, appears to be a broad scoop-shaped organ, with the margins fringed with spines on the apical half. When examined from within, however, a very intricate structure is seen to repose in the concavity of the outer part, a structure so complicated that to attempt a description would be futile. The right harpe is much smaller than the left, and though complex and quite different from the usual type it does not reach the extreme specialization of its fellow. The aedeagus, which is attached to the right harpe, is short and flask-shaped, its apical part being sharply bent.

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## The Male Genitalia of the New Zealand Glyphipterygidae.

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by Editor, 10th September, 1927; issued separately,  
12th November, 1927.]

### INTRODUCTORY.

THE Glyphipterygidae are represented in New Zealand by eight genera. Of these, one, *Choreutis*, may not naturally belong to the fauna, the only species present, *C. bjerkanndrella* Thunb., being quite possibly an introduction from Europe. Of the remaining seven, four are endemic, three of these being monotypic, and the other containing only three species. Half of our total species belong to *Glyphipteryx*, this genus embracing 31 out of an aggregate of 62.

The male genitalia, as far as is shown by the New Zealand forms, is of rather simple type. The eighth segment is not modified and the tegumen and vinculum are frequently imperfectly fused or altogether free. Except in *Hierodoris*, the gnathos is absent, and there is little development of the uncus. The saccus is usually small, and, where elongate, narrow; in several instances it is entirely absent. The aedeagus is generally of simple tubular type and is supported by a juxta which may be a plain folded plate or a more elaborate sheath-like structure. The harpes are almost always simple and entire; in only a few instances is there a lobe-like sacculus present.

Three monotypic genera, *Charixena* Meyr., *Coridomorpha* Meyr. and *Pantosperma* Meyr. are not here dealt with, no material of these being at the writer's disposal.

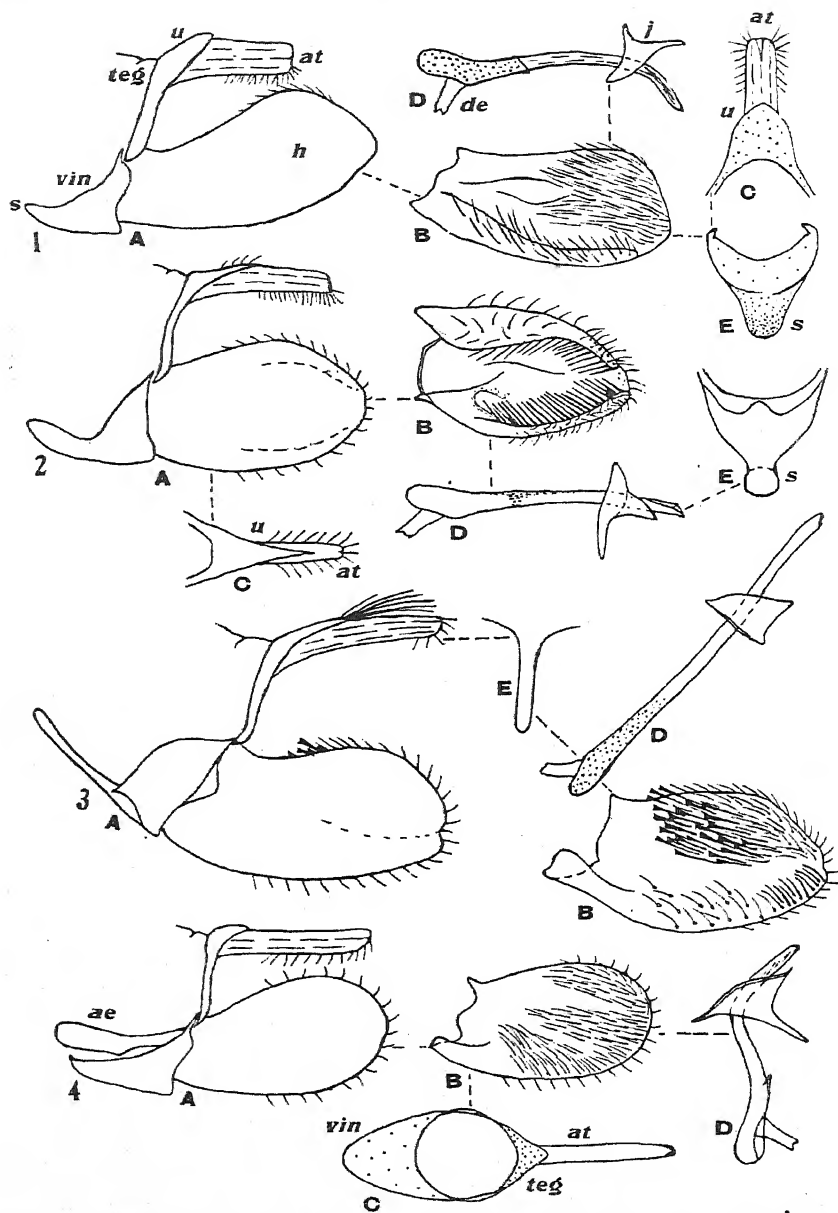
### Genus *Simaethis* Leach (Figs. 1-10).

Cosmopolitan, but chiefly characteristic of the Australasian and Indo-Malayan regions; there is also considerable development in South America. Seventeen species, all of which are endemic; ten of these have been available for examination.

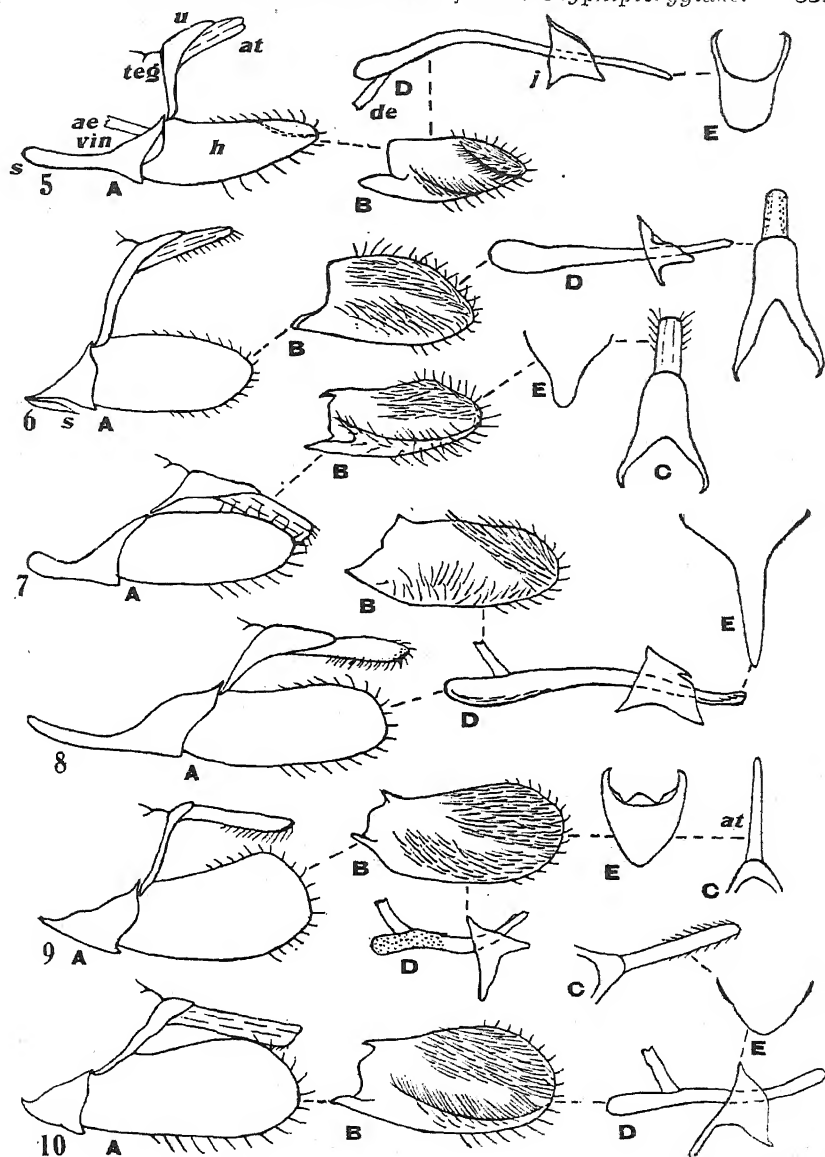
Tegumen not fused with vinculum, moderately broad dorsally; uncus usually only slightly developed, but in some species fairly long and acute. Gnathos absent. Vinculum broad, with short moderately broad apically rounded saccus. Aedeagus moderate, of simple tubular shape, frequently more or less curved. Juxta a plain plate which is folded round the aedeagus, assuming the shape of a conical hat. Harpes broad, apically rounded, entire, the sacculus indicated by a

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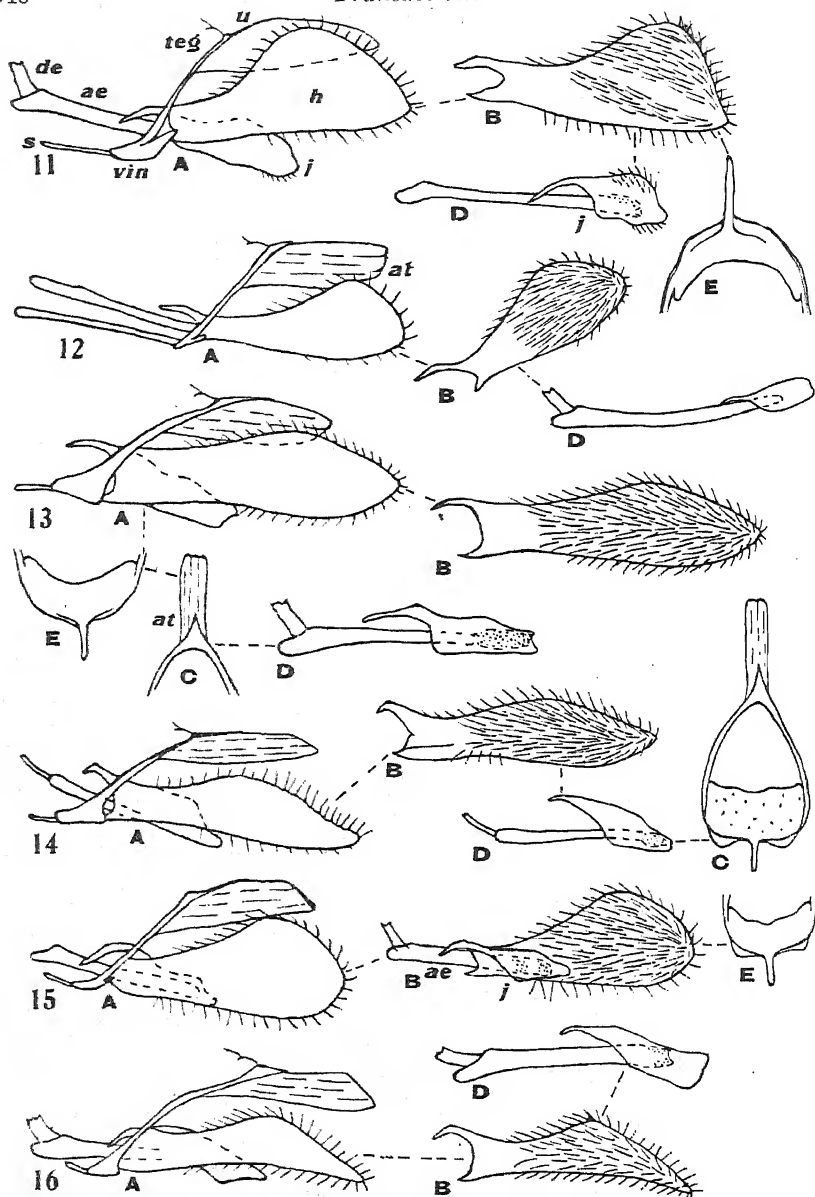
ae. aedeagus; at, anal tube; de, ductus ejaculatorius; g, gnathos; h, harpe; j, juxta; s, saccus; teg, tegumen; u, uncus; vin, vinculum.



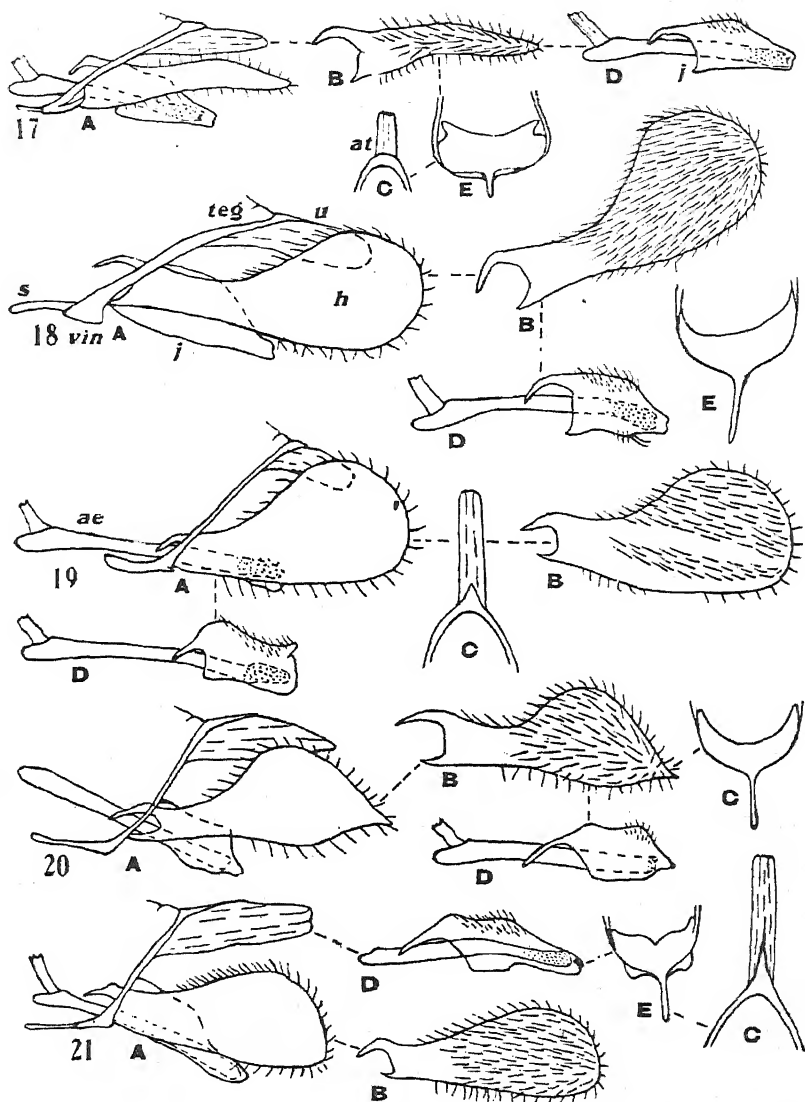
- FIG. 1.—*Stimaethis barbiger* Meyr. A, male genitalia, lateral view; B, harpe inner view; C, tegumen, dorsal view; D, aedeagus and juxta; E, vinculum, dorsal view.
- FIG. 2.—*S. exocha* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta; E, vinculum, dorsal view.
- FIG. 3.—*S. albifasciata* Philp. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta; E, saccus.
- FIG. 4.—*S. microlitha* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, vinculum and tegumen, dorsal view; D, aedeagus and juxta.



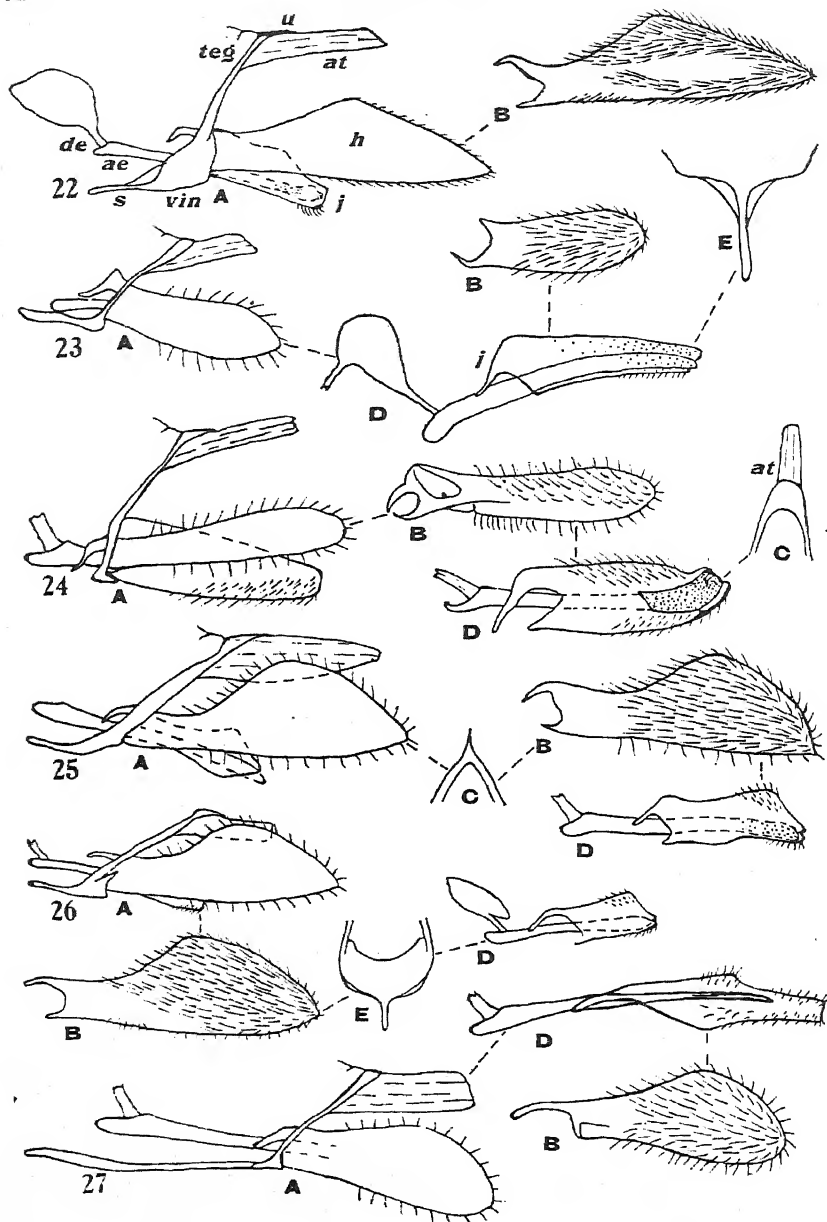
- FIG. 5.—*S. combinatana* Walk. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta; E, tegumen, dorsal view.
- FIG. 6.—*S. marmarea* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta.
- FIG. 7.—*S. colpota* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; E, saccus, ventral view.
- FIG. 8.—*S. antigrapha* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta; E, saccus, ventral view.
- FIG. 9.—*S. symbolaea* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta; E, vinculum, ventral view.
- FIG. 10.—*S. analoga* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta; E, saccus, ventral view.



- FIG. 11.—*Glyptipteryx dichorda* Meyr. A, male genitalia, inner view; B, harpe, inner view; D, aedeagus and juxta; E, vinculum, dorsal view.
- FIG. 12.—*G. leptosema* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta.
- FIG. 13.—*G. autogramma* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta; E, vinculum, ventral view.
- FIG. 14.—*G. bactrias* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, vinculum and tegumen, dorsal view; D, aedeagus and juxta.
- FIG. 15.—*G. aenea* Philp. A, male genitalia, lateral view; B, harpe, aedeagus and juxta, inner view; E, vinculum, dorsal view.
- FIG. 16.—*G. rugata* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta.



- FIG. 17.—*G. nephotera* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta; E, vinculum, dorsal view.
- FIG. 18.—*G. metastica* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta; E, vinculum, dorsal view.
- FIG. 19.—*G. achlyoessa* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta.
- FIG. 20.—*G. brachydelta* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, vinculum, ventral view; D, aedeagus and juxta.
- FIG. 21.—*G. barbata* Philp. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta; E, vinculum, ventral view.



- FIG. 22.—*G. transversella* Walk. A, male genitalia, lateral view; B, harpe, inner view.
- FIG. 23.—*G. octonaria* Philp. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta; E, vinculum, ventral view.
- FIG. 24.—*G. ataracta* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta.
- FIG. 25.—*G. oxymachaera* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta.
- FIG. 26.—*G. codonias* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta; E, vinculum, ventral view.
- FIG. 27.—*G. iocheaera* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta.

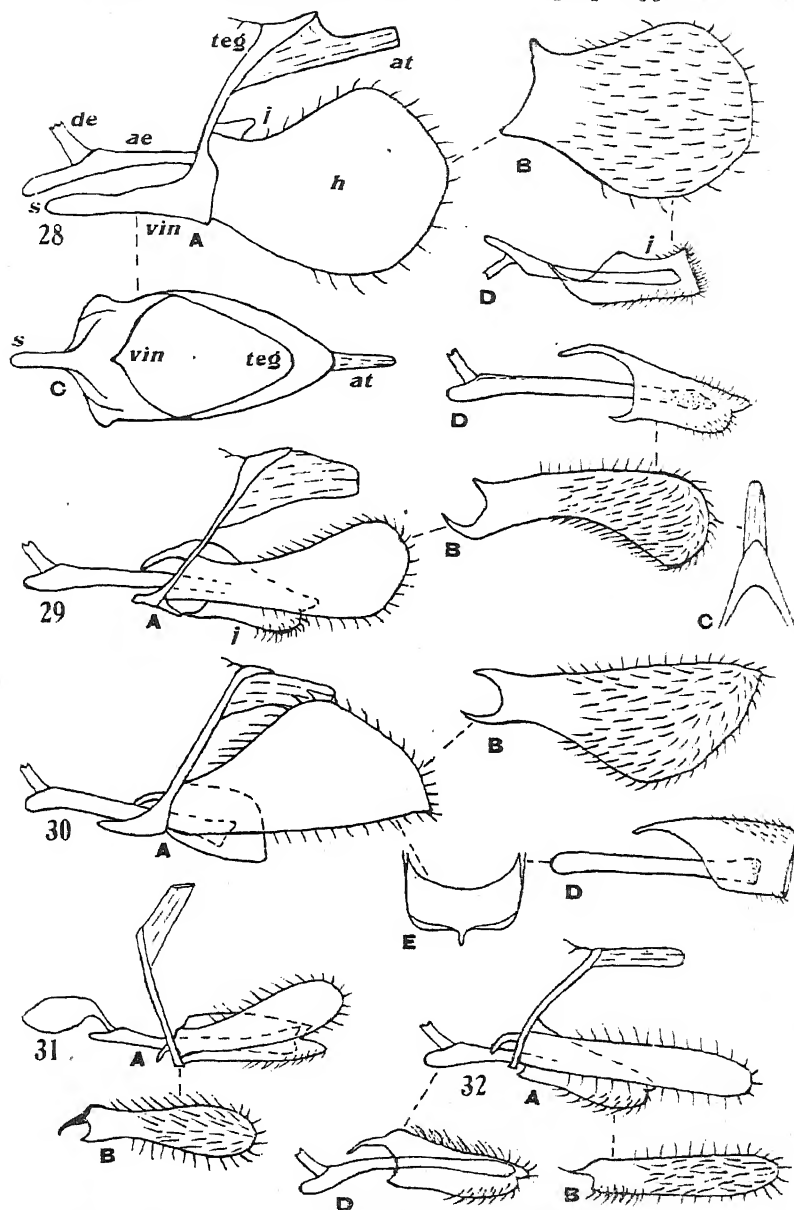


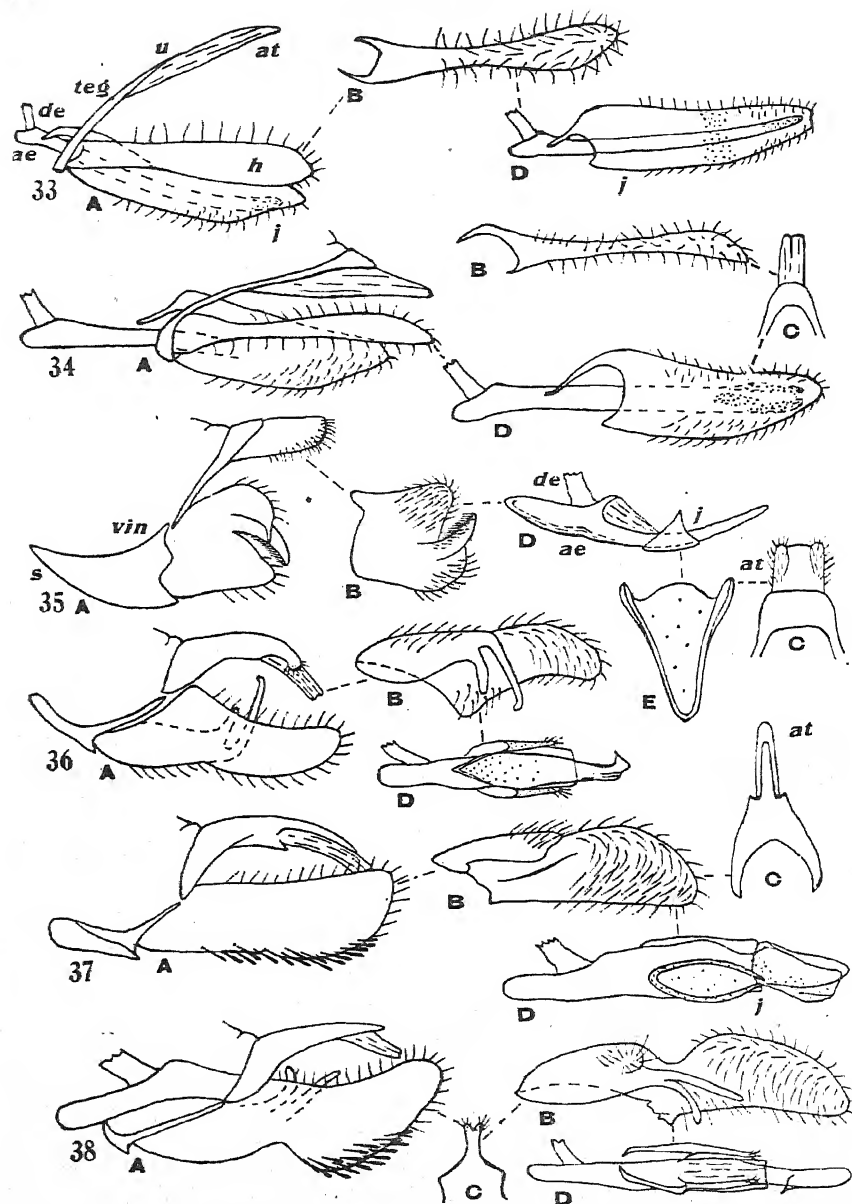
FIG. 28.—*G. zelota* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, vinculum and tegumen, dorsal view; D, aedeagus and juxta.

FIG. 29.—*G. triselenu* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta.

FIG. 30.—*G. acronoma* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta; E, vinculum, ventral view.

FIG. 31.—*G. necopina* Philp. A, male genitalia, lateral view; B, harpe, inner view.

FIG. 32.—*G. cionophora* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta.



- FIG. 33.—*G. erastis* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta.
- FIG. 34.—*G. acrothecta* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta.
- FIG. 35.—*Choreutis bjerkanndrella* Thunb. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta; E, vinculum, ventral view.
- FIG. 36.—*Heliothibes electrica* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta.
- FIG. 37.—*H. atychioides* Butl. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus and juxta.
- FIG. 38.—*H. illita* Feld. A, male genitalia, lateral view; B, harpe, inner view; C, uncus, dorsal view; D, aedeagus and juxta.

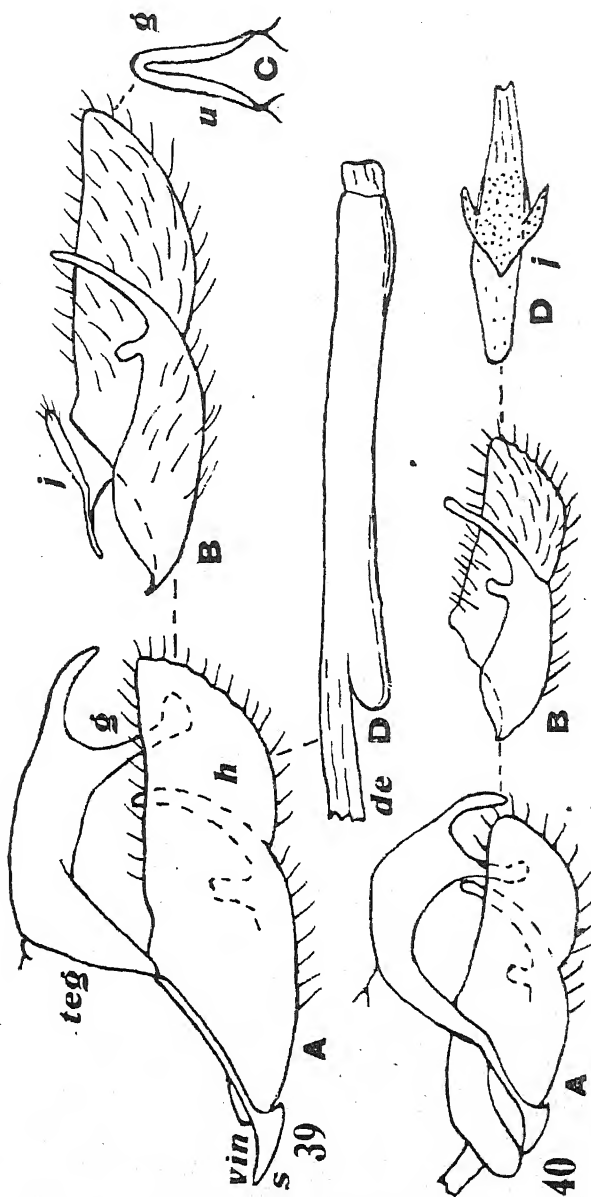


FIG. 39.—*Hierodoris iophanes* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, uncus and gnathos, dorsal view; D, aedeagus.

FIG. 40.—*H. frigida* Philp. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus and juxta.

fold, but not free, clothed within with tracts of moderately long hair, in some instances with modified scales. Outwardly the harpes are thickly scaled; in the figures, for the sake of clearness, these scales have been omitted.

Genus **Glyphipteryx** Hb. (Figs. 11-34.)

Cosmopolitan, but most numerous in the Australasian and Indo-Malayan regions. Thirty-one species, all endemic; twenty-four have been dissected.

Tegumen very narrow, fused with vinculum, sometimes not fused dorsally; uncus absent, or present as an acutely pointed process, never very long. Vinculum small, in only one species, *G. zelota* Meyr., is it of moderate dimensions; saccus frequently absent or short and thin, but in some species moderately long. Gnathos absent. Aedeagus moderate or short, simple, tubular, tending to be apically swollen but sometimes tapered. Juxta forming a sheath of greater or lesser length in which the aedeagus lies; the lateral arms of the juxta are fused with the processes from the upper basal angles of the harpes, so that in dissection these parts sometimes adhere to one organ and sometimes to the other; quite frequently, however, they split into two halves. Harpes simple, entire, varying in shape from very narrow to broadly rounded; inner surface usually covered, except near base, with weak hair.

Genus **Choreutis** Hb. (Fig. 35.)

The almost world-wide *C. bjerkanndrella* Hb. is the only representative of the genus

Tegumen narrow, not fused with vinculum; uncus not developed; anal tube short, broad. Gnathos absent. Aedeagus moderate, curved, swollen apically, basally with projection above entrance of ductus ejaculatorius. Juxta a small folded plate closely embracing aedeagus. Vinculum broad with moderately broad and deep saccus. Harpes short, quadrangular, deeply cleft obliquely on lower apical angle, above cleft a curved finger-like lobe densely haired on lower margin, above this lobe a second with thin pointed apex and expanded basal part.

Genus **Heliosibes** Z. (Figs. 36-38.)

Seven New Zealand and one South American species are known. Three species have been available for examination. *H. electrica* Meyr. and *H. illita* Feld. do not differ much in the characters of the male genitalia, but *H. atychioides* Butl. exhibits considerable divergence. The two types will therefore be described separately as "A" and "B" respectively.

A.—Tegumen moderate, not fused with vinculum; uncus small, narrow. Vinculum very narrow with small saccus. Gnathos absent. Aedeagus moderate with long basal "heel." Juxta an enveloping band with a pair of fairly long lobes. Harpes moderate to large, sacculus with two obliquely transverse lobes, ventral margin more or less indented.

B.—Tegumen not fused with vinculum; uncus moderately long, narrow. A true gnathos absent, but a slight chitinisation of the closing membrane appears to function in a similar manner. Aedeagus stout, irregular, with complicated apical portion. Juxta a simple oval plate, more strongly chitinised round margin. Harpes moderate, entire, sacculus a simple fold without lobes.

Genus **Hierodoris** Meyr.

Endemic. Three species, of which one, *H. stellata* Philp., is only known by the type specimen.

Tegumen fused with vinculum, but point of union apparent; uncus well developed, curved, finger-like. Gnathos a plain band upturned at apex. Vinculum small, lateral arms narrow; saccus small. Aedeagus stout, moderate or long. Juxta a plain plate with a pair of short finger-like lobes. Harpes with sacculus forming a long transverse lobe reaching beyond upper margin and having a short lobe beneath it at base. A very similar type of harpe is to be found in some species of *Gymnobathra*, e.g., *G. coarctatella* Walk., and *G. parca* Butl. (See *Trans. N.Z. Inst.*, vol. 57, p. 716.)

## The Male Genitalia of the New Zealand Gelechiidae.

By ALFRED PHILPOTT,

Hon. Research Student in Lepidoptera, Cawthron Institute,  
Nelson, New Zealand.

[Read before the Nelson Philosophical Society 31st August, 1927; received by Editor, 10th September, 1927; issued separately, 12th November, 1927.]

THE Gelechiidae form the largest family of the Tineoidea, there being about 400 genera and more than 3,500 known species. Meyrick, in his revision of the family (Genera Insectorum, fasc. 184 (1925)), regards the group as one of "rather modern development, which has succeeded in adapting itself to a great variety of situations." The distribution of the family is practically world-wide, though there are few representatives in oceanic islands. Only ten genera are found in New Zealand and, so far, no endemic genus has been discovered. Of the thirty-three species now known as occurring in New Zealand, one is also found in Australia and two others are accidentally introduced widely spread forms. Of the remaining thirty, *Gelechia* and its ally *Phthorimaea* account for eighteen species, leaving twelve to be distributed among seven other genera.

In view of the paucity of the New Zealand representation of the family, it is not advisable to attempt any general diagnosis of the genitalia structure therefrom; attention will therefore be at once directed to the individual genera.

### *Oegoconia* Stainton. (Fig. 1.)

The European *O. quadripuncta* Haw. has been accidentally introduced into New Zealand. The genus exhibits certain affinities with the Oecophoridae and the male genitalia are certainly very similar to those of such Oecophorid genera as *Borkhausenia* and *Gymnobathra*.

Tegumen not fused but closely attached to vinculum, moderately broad, with well developed curved narrow uncus. Gnathos united and produced as a straight prong, upcurved at apex. Aedeagus moderate, tubular, at apex a membranous extension bent backwards at an acute angle with a brush of hair at extremity. Juxta a small triangular plate. Vinculum small, narrow, saccus hardly developed. Harpes broad, entire, with a short pointed lobe (sacculus?) beyond middle within.

### *Anisoplaca* Meyrick. (Figs. 2-4.)

A small genus with scattered members in South America, South Africa and Java. There are three New Zealand species.

Tegumen free or imperfectly fused with vinculum, broad; uncus well developed, apically dilated. Gnathos with a strong sickle-shaped prong. Vinculum small, narrow, saccus only slightly developed. Aedeagus very small, much swollen at base, with long firm ejaculatory

duct. Juxta absent. Harpes simple, entire, moderate to broad; *A. ptyoptera* differs from the other two in the shape of the harpes, which are more leaf-like and have a small tuft of stiff hairs on lower apical angle.

**Gelechia** Hubner. (Figs. 5-12.)

This world-wide genus, of which there are over 400 known forms, has ten representatives in New Zealand; eight of these are here dealt with. In the New Zealand section the genitalia are remarkably alike in all the species, and are therefore of comparatively little value to the systematist. Careful comparison will, however, usually reveal small differences. The apex of the main prong of the harpes and the saccus offer the best points of comparison; the position of the gnathos (as figured) is not necessarily of value, as this organ is moveable and does not always appear in the same relative place in a preparation.

The eighth segment is much modified. It is deeply cleft laterally, and the tergite and sternite are produced caudally as concave plates above and below the genitalia. These plates, or sheaths, are usually covered with short hairs and in some instances a pencil of long hairs springs from the tergite near its base, reaching to beyond its apex. Tegumen not fused with vinculum, broad, with broadly rounded short uncus. Gnathos a strong sickle-shaped prong. Aedeagus very short, pistol-shaped. Vinculum fused to base of harpes and harpes fused along ventral basal margin, thus forming a strong concavity within which lies the aedeagus. Saccus short and narrow. Harpes with long thin main prong and a pair of short basal ones.

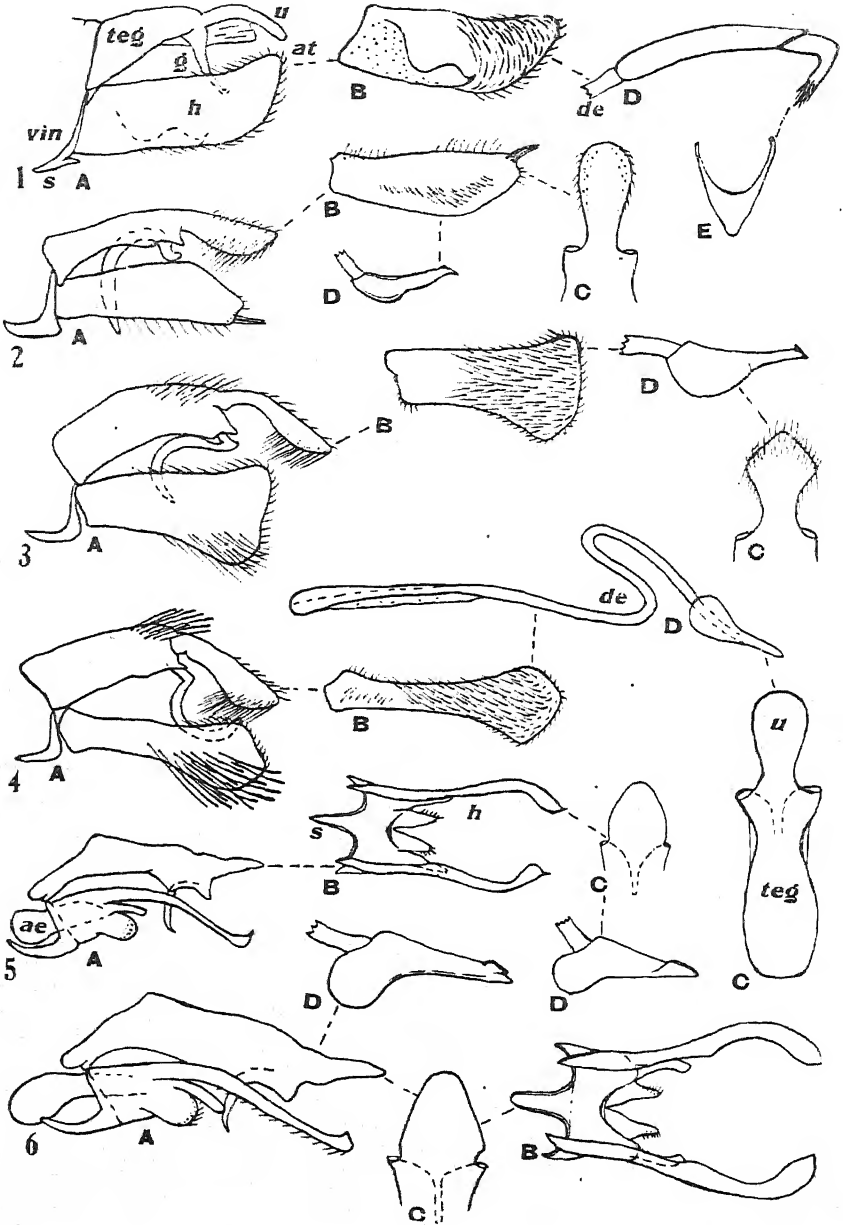
**Phthorimaea** Meyrick. (Figs. 13-16.)

A large genus, containing upwards of 200 species, the majority of which are palaearctic though representatives are found in Africa, India, America and Australia. In addition to the introduced potatoe pest, *P. operculella* Z., there are eight endemic species in New Zealand. Only four species have been examined.

The genitalia are of the same type as *Gelechia*; the aedeagus is usually slightly longer and the saccus a little more developed. Tegumen long, narrow to moderate; uncus broad, rounded. Gnathos as in *Gelechia* but tending to be weaker. Aedeagus small, pistol-shaped. Juxta absent. Vinculum fused with harpes as in *Gelechia*. Harpes as in *Gelechia*. *P. operculella* departs from the typical structure in several details. The eighth segment is more produced, or more deeply cleft; the sternite is clothed with dense long hair-scales and the tergite with short erect scales. The gnathos has an inflated round basal piece from which rises a spoon-shaped structure fitting closely within the tegumen. The aedeagus is much longer than usual, and the vinculum is correspondingly developed.

**Thiotricha** Meyrick. (Fig. 17.)

"Characteristically Indo-Malayan, with a considerable Australian section (many Queensland) and scattered elements in Europe, Africa, South America and New Zealand." (Meyrick.) Of the three New Zealand species only one has been available for examination.



FIGS. 1-6.

Eighth segment with sternite only produced, this being upcurved apically and cleft into a pair of processes. Tegumen not fused with vinculum; uncus a concave circular plate. Gnathos fused near base and extending between harpes as a long sickle-shaped prong. Vinculum small, saccus only slightly developed. Aedeagus short, stout, basally swollen. Juxta formed by flat expansions from lower basal angles of harpes which meet and are united on the meson. Harpes consisting of a long narrow sinuate main lobe with widely expanded apical portion and another lobe about half as long slightly attached at base; the shorter lobe is hairy and has a pair of strong curved bristles at its apex.

**Aristotelia** Hubner. (Fig. 18.)

This large genus, containing about 250 known species is practically world-wide, though but a single form has been recorded from New Zealand.

Eighth segment little modified. Tegumen not fused with vinculum, moderately broad; uncus broad, slightly dilated apically. Gnathos broad, forming at apex a spatulate upturned plate. Vinculum narrow, arms incurved; saccus short, narrow. Aedeagus rather large, tapering to apex, which is truncate. Juxta a pair of membranous cone-shaped pieces lying along upper basal margin of harpes. Harpes with main prong moderately broad, lower apical angle produced to a point, a broad weakly chitinated basal plate or flap (about half as long as main prong) extending ventrally and terminating in a sharp point.

**Megacraspedus** Zeller. (Fig. 19.)

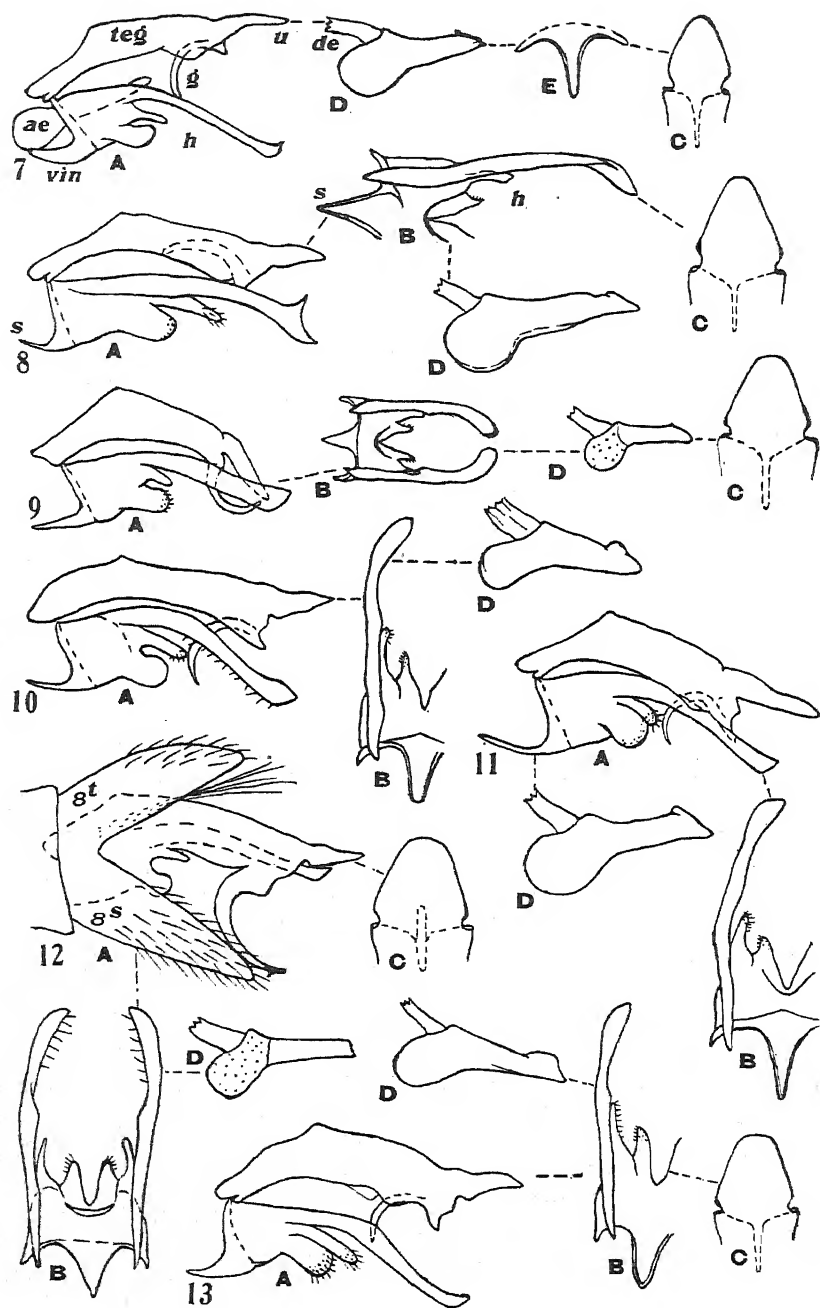
As in the case of the preceding genus, New Zealand possesses but a single example of a widely spread group.

Eighth segment not much modified, sternite slightly produced and armed round caudal region with long hair. Tegumen not fused with vinculum, broad, with square process at middle of basal margin; uncus broad, rounded. Gnathos fused near base and forming a strongly chitinated curved prong. Aedeagus short, very stout, flask-shaped. Juxta absent. Vinculum very weak with narrow arms, basal portion dechiti-

LETTERING.

*ae*, aedeagus; *at*, anal tube; *c*, colon; *de*, ductus ejaculatorius; *g*, gnathos; *h*, harpes; *j*, juxta; *s*, saccus; *sg*, surgonopods; *teg*, tegumen; *t*, transtilla; *u*, uncus; *vin*, vinculum; *8s*, eighth sternite; *8t*, eighth tergite.

- FIG. 1.—*Oegoconia quadripuncta* Stt. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus; E, vinculum.  
 FIG. 2.—*Anisoplaça ptyoptera* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, uncus, dorsal view; D, aedeagus.  
 FIG. 3.—*A. achyrota* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, uncus, dorsal view; D, aedeagus.  
 FIG. 4.—*A. acrodactyla* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus.  
 FIG. 5.—*Gelechia aerobatis* Meyr. A, male genitalia, lateral view; B, harpes and vinculum, from above; C, uncus, dorsal view; D, aedeagus.  
 FIG. 6.—*G. lithodes* Meyr. A, male genitalia, lateral view; B, harpes and vinculum, from above; C, uncus, dorsal view; D, aedeagus.



FIGS. 7-13.

nised so that arms are only membranously united. Harpes narrow, triangularly expanded at apex, a weak pointed inner lobe and lower basal angle extended beneath aedeagus, thus acting as a juxta.

**Lecithocera** Herrich-Schaffer. (Fig. 20.)

A large Indo-Malayan genus with some extension to Africa and Australia. The single New Zealand species is found in Australia also.

Eighth segment divided along median ventral line. Tegumen not fused with vinculum, broad. The anal opening seems to be through the back of the tegumen, but this apparent abnormality is owing to the broad gnathos forming a fused ring directed almost in a line with the tegumen. Gnathos hatchet-shaped, broad. Aedeagus short, stout, curved. Juxta a concave plate with lateral lobes embracing aedeagus. Harpes large, broad entire, curved upwards

**Sitotroga** Heinemann. (Fig. 21.)

Monotypic. The almost cosmopolitan pest of stored grain, *S. cerealella* Ol., has been accidentally introduced into New Zealand.

Tegumen moderately broad with narrower uncus which is slightly indented apically, not fused, but closely attached to vinculum. Gnathos sickle-shaped, weak. Aedeagus moderate, spindle-shaped. Vinculum narrow, with short saccus. Juxta absent. Harpes rounded, entire, but with long apical prong bent rectangularly downwards, clothed with dense hair on apical half.

**Stomopteryx** Heinemann. (Fig. 23.)

A considerable genus of worldwide distribution though chiefly characteristic of the Palaearctic region.

The only New Zealand representative is a new species described elsewhere in this volume. By an unfortunate transposition of drawings the male genitalia of *Gelechia neglecta* Philp. are figured (under the name of *Stomopteryx simplicella* Walk.) for those of the present species in *Trans. N.Z. Inst.*, 55, 666.

Tegumen not fused with vinculum, broad; uncus narrow, apex slightly bifid. Gnathos strong, sickle-shaped. Vinculum with very narrow arms which are closely attached to bases of harpes; saccus broad, apex almost truncate. Juxta absent, but between the arms of the vinculum is an irregular membranous process, through an aper-

---

FIG. 7.—*G. monophragma* Meyr. A, male genitalia, lateral view; C, uncus, dorsal view; D, aedeagus; E, vinculum.

FIG. 8.—*G. parapleura* Meyr. A, male genitalia, lateral view; B, harpe and vinculum, from above; C, uncus, dorsal view; D, aedeagus.

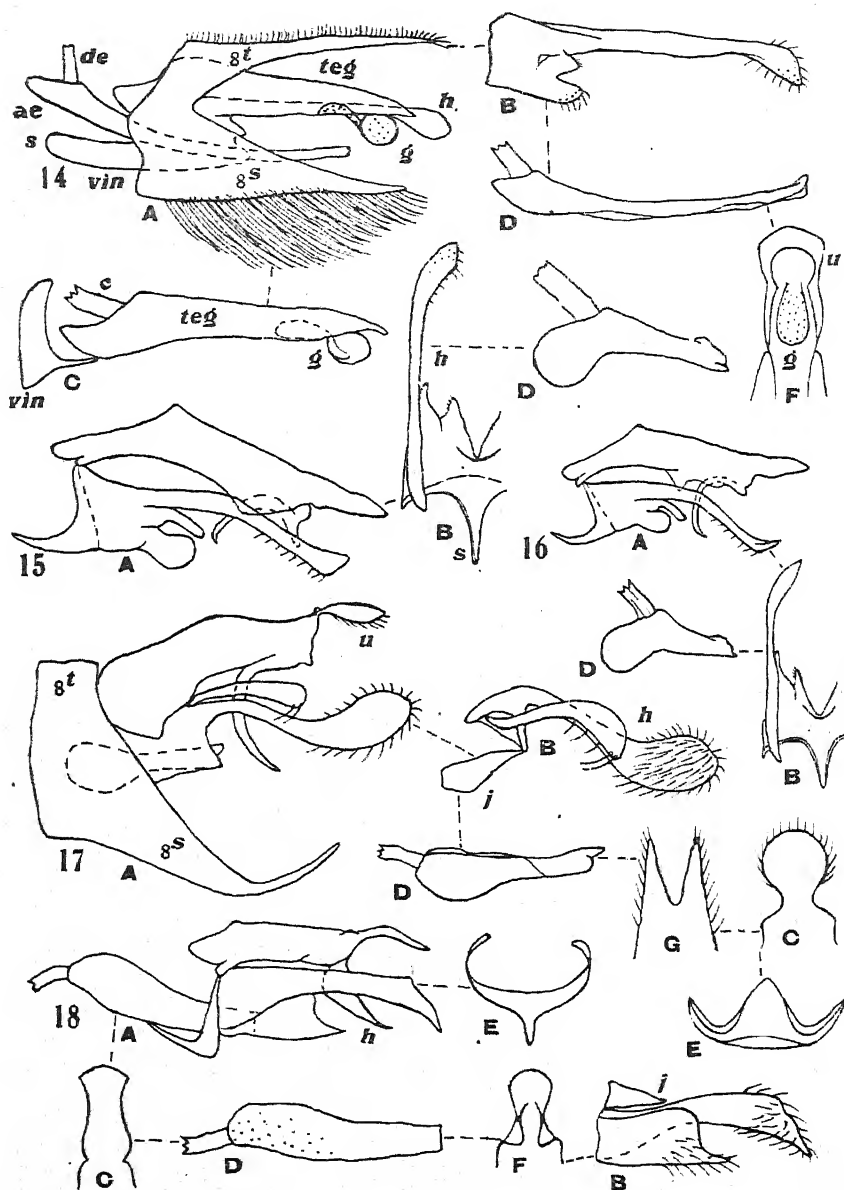
FIG. 9.—*G. neglecta* Philp. A, male genitalia, lateral view; B, harpes and vinculum, from above; C, uncus, dorsal view; D, aedeagus.

FIG. 10.—*G. lapillosa* Meyr. A, male genitalia, lateral view; B, harpe and vinculum, from above; D, aedeagus.

FIG. 11.—*G. dividua* Philp. A, male genitalia, lateral view; B, harpe and vinculum, from above; D, aedeagus.

FIG. 12.—*G. schematica* Meyr. A, male genitalia, lateral view; B, harpes and vinculum, from above; C, uncus, dorsal view; D, aedeagus.

FIG. 13.—*Phthorimaea cheradias* Meyr. A, male genitalia, lateral view; B, harpe and vinculum, from above; C, uncus, dorsal view; D, aedeagus.



FIGS. 14-18.

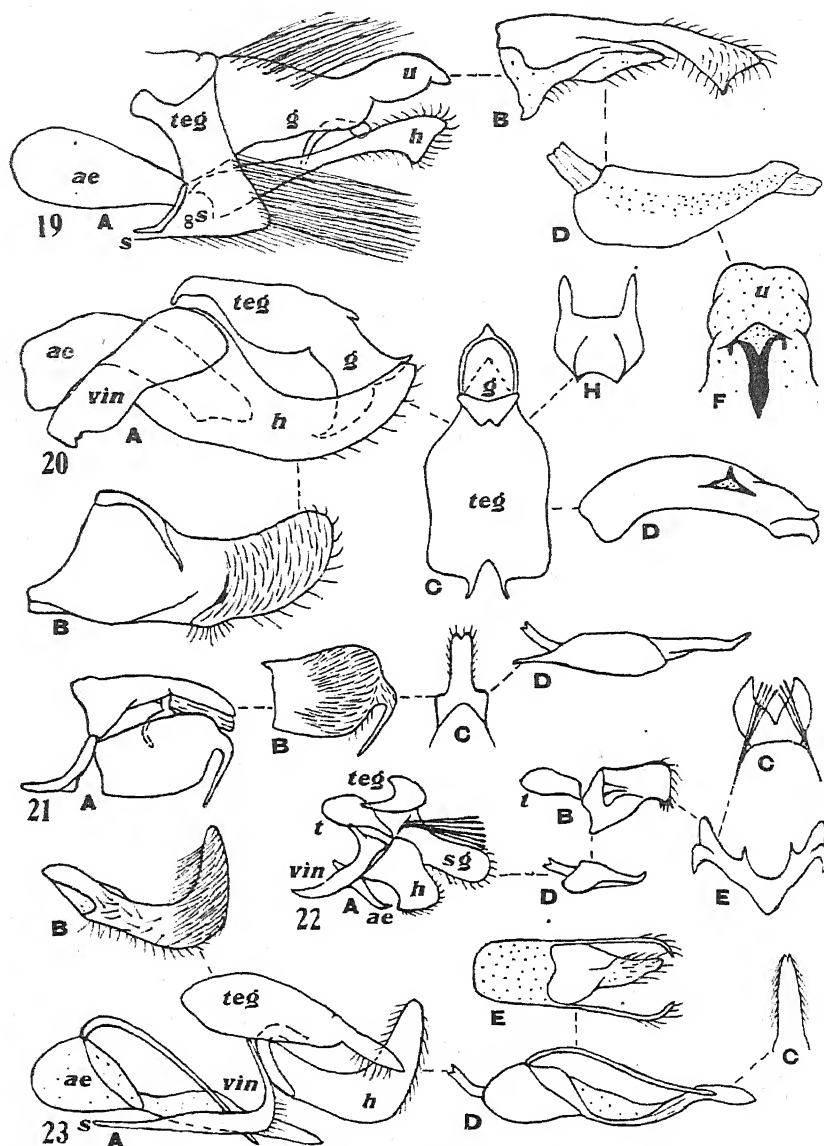
ture at the base of which the aedeagus passes. Aedeagus moderately long, sinuate, base much swollen and with a thin long arched process rising from it, curving upwards and then downwards back to aedeagus near apex. Harpes entire, rather narrow and rectangularly bent upwards at middle.

**Apatetris** Staudinger. (Fig. 22.)

A comparatively small genus (about 40 species) with headquarters in Australia and outlying species in Africa, Europe and India. One species is found in New Zealand.

Genitalia small. Tegumen and vinculum closely attached, but not fused, to what appears to be the greatly modified transtilla; the tegumen is small and cleft into two lobes apically. Uncus not developed, but a pair of large surgonopods is present; these being deeply concave form a shelter within which lies the anal tube. Aedeagus very small, beaked at apex and much swollen basally. It is placed unusually ventrad of the harpes. Vinculum narrow, lateral arms with a small prong midway on caudal margin; saccus small. Harpes short, entire, with a prominent inner fold on basal portion; closely attached to base is a pear-shaped plate (transtilla?) which here functions as a brace or stay between the tegumen and vinculum.

- 
- FIG. 14.—*P. operculella* Z. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen and vinculum, lateral view; D, aedeagus; E, gnathos and uncus, from beneath.
- FIG. 15.—*P. glaucotermis* Meyr. A, male genitalia, dorsal view; B, harpe and vinculum, from above; D, aedeagus.
- FIG. 16.—*P. brontophora* Meyr. A, male genitalia, lateral view; B, harpe and vinculum, from above; D, aedeagus.
- FIG. 17.—*Thiotricha tetraphala* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, uncus, dorsal view; D, aedeagus; E, vinculum; G, apex of eighth sternite.
- FIG. 18.—*Aristotelia paradesma* Meyr. A, male genitalia, lateral view; B, harpe, inner view; C, uncus, dorsal view; D, aedeagus; E, vinculum; F, gnathos, from beneath.



- FIG. 19.—*Megacraspedus calamogona* Meyr. A, male genitalia, lateral view; B, harpe, inner view; D, aedeagus; F, gnathos, from beneath.
- FIG. 20.—*Lecithocera micromela* Low. A, male genitalia, lateral view; B, harpe, inner view; C, tegumen, dorsal view; D, aedeagus; H, juxta.
- FIG. 21.—*Sitotroga cerealella* Ol. A, male genitalia, lateral view; B, harpe, inner view; C, uncus, dorsal view; D, aedeagus.
- FIG. 22.—*Apatetris melanombra* Meyr. A, male genitalia, lateral view; B, harpe and transtilla, inner view; C, uncus, dorsal view; D, aedeagus; E, vinculum.
- FIG. 23.—*Stomopteryx* n. sp. A, male genitalia, lateral view; B, harpe, inner view; C, uncus, dorsal view; D, aedeagus; E, vinculum.

## A Kaipara Ammonite.

By P. MARSHALL, M.A., D.Sc., F.N.Z. Inst.,  
Hector and Hutton Medallist, N.Z. Institute.

[Read before the Wellington Philosophical Institute, 7th September, 1927;  
received by Editor, 28th September, 1927; issued separately,  
12th November, 1927.]

Plates 36, 37.

SINCE the paper on the Upper Cretaceous ammonites of New Zealand was written a party of geological students, working with Mr. J. A. Bartrum, Professor of Geology at the Auckland University College, collected a number of specimens. These, however, were all referable to species that were described in the paper cited above. In one case, however, a specimen was in far better condition than the type of a species described previously under the name *Novakites denticulatus*. Examination of this specimen shows that the species should be placed in the genus *Grossouvrites* established by Kilian and Reboul in 1909. A fuller description of the species can now be given.

### *Grossouvrites denticulatus* Marshall. (Plates).

*Novakites denticulatus* Marshall, Upper Cretaceous Ammonites of New Zealand, *Trans. N.Z. Inst.* vol. 56, 1926, p. 189, Pl. 25, fig. 3, Pl. 38, figs 5, 6.

#### Compare:

1895. *Holcodicus gemmatus* Huppé, in Steinmann *Neues Jahrb. für min.*, etc. Band 10, Stuttgart, 1895.  
1909. *Kossmaticeras (Grossouvrites) gemmatum* Huppé, sp. in Kilian and Reboul, in *Les Cephalopodes Néocretacées des Îles Seymour et Snow Mill. Wiss. Ergeb. der Schwedischen sudpolar-expedition*, Stockholm, 1909.  
1900. *Pachydiscus gemmatus* Huppé, in Andersen, *Graham Land*, p. 35.

Dimensions (all in millimeters):—

	A		B	
Diameter .....	142	100	44	100
Height of last whorl	66	46	24	54
Width of last whorl	62	44	21	48
Umbilicus .....	42	30	6	13.8

A.—*Grossouvrites denticulatus*, Bull's Point, Kaipara Harbour. New Zealand.

B.—*Grossouvrites gemmatus*. Measurements from cast of specimen from Seymour Island kindly presented by the late Professor Kilian.

The present specimen is far more perfect than the one described by Marshall (*l.c.*, p. 189) under the name of *Novakites denticulatus*. The description of the costation that was given requires no additions. In the present specimen, however, the suture-line both internal and

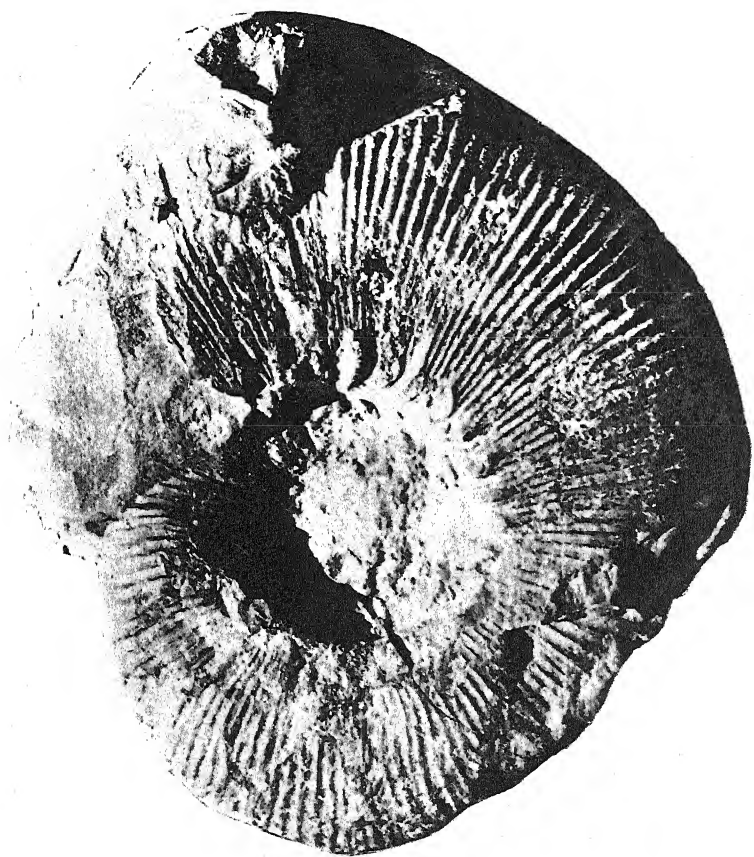
external can be followed in some detail, except in the upper portion of the external saddle. Examination of these shows that they approach the *Jacobites* and *Gunnarites* type and are really quite distinct from those of *Pachydiscus*. The resemblance to that of *Jacobites* is most pronounced in all the main features of the external and internal portion of the suture-line, and it is to this genus that *Grossouvrites* has the closest relationship. On the other hand in all of the specimens that have been collected up to the present time the ornamentation does not show any approach to that of *Jacobites*, especially in the absence of the tendency towards the development of spinous processes on the mature whorls.

The suture-line shows a close resemblance to that of *Kossmaticeras gemmatum* as drawn by Steinmann and copied by Kilian and Reboul (*l.c.*, p. 22, fig. 15). In that case, however, the whole of the external portion of the suture-line is not shown and none of the internal portion has been drawn.

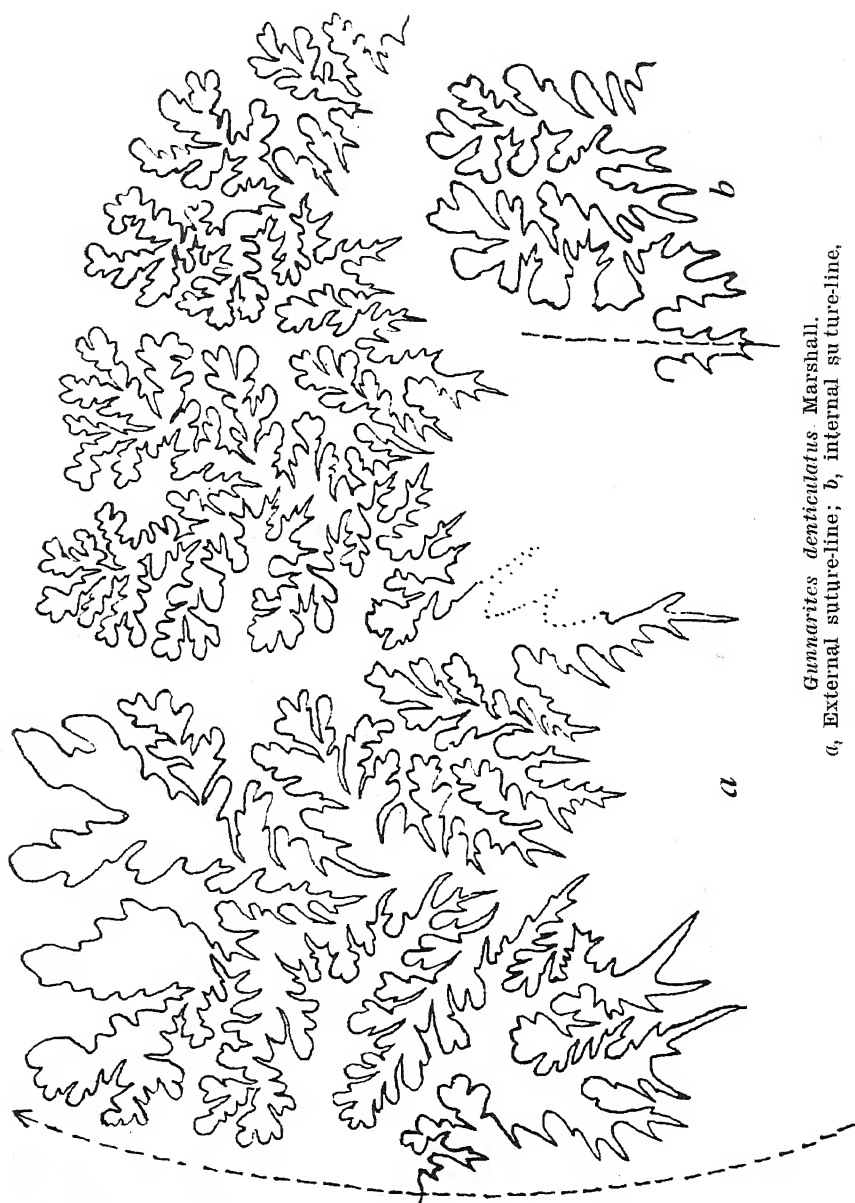
The resemblance, however, is so close that it justifies the classification of this species in the genus *Grossouvrites*. The ornamentation, however, is different; for in *Grossouvrites gemmatum* half of the ribs do not extend to the umbilicus, while in this species they are all continuous. Again, the ribs of *G. gemmatum* are not finely denticulate as in this species. The dimensions show a general similarity to those of *G. gemmatum* though the differences are quite sufficient to show a specific if not a generic divergence.

The suggestion that was made in the previous paper (Marshall, *l.c.*, p. 168) that *G. gemmatum* would be more properly placed in the genus *Pachydiscus* must now be revised. It becomes clear that *Grossouvrites* is quite distinct from *Pachydiscus* and is closely related to *Gunnarites* and *Jacobites* which may be derived from *Acanthoceras* or from the same stock as that genus.

In October, 1926, an opportunity was taken of comparing examples of the species of the New Zealand ammonites with specimens from the Upper Cretaceous rocks of Japan with the great advantage of consultation with Professor H. Yabe and Dr. Shimizu at the Imperial University Sendai, Japan. The opinion that was previously expressed that the New Zealand species of *Gaudryceras* were distinct from, though related to, those of Japan was amply verified. In other respects the opinions formed from the study of the papers written by Japanese specialists were in general strongly supported except in regard to *Acanthoceras ultimum*. This was found to belong to an undescribed genus of the *Kossmaticeras* group, and for this genus I now propose the name *Aucklandites*.



*Gunnarites denticulatus* Marshall, two-thirds nat. size.



*Gunnarites denticulatus* Marshall.  
a, External suture-line; b, internal suture-line.





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## Notes and Descriptions of New Zealand Lepidoptera.

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera,  
Cawthron Institute, Nelson.

[Read before the Nelson Philosophical Society, 23th September, 1927;  
received by Editor, 2nd October, 1927; issued separately,  
14th February, 1928.]

### NOCTUIDAE.

*Aletia mitis* (Butl.), *Proc. Zool. Soc. Lond.*, 1877, p. 383, pl. 42, 5.

This species seems to have been unrecognised by New Zealand collectors since Butler's description half a century ago. In the absence of specimens it has been variously regarded as a synonym of *cucillina* Guen. or *moderata* Walk., but to the writer there seems to be now no doubt that Butler's insect is a valid species. Dr. A. Jefferis Turner, of Queensland, during a recent visit to New Zealand took a fine specimen at Arthurs Pass on 15th February. This example Doctor Turner kindly presented to the Cawthron Institute. Butler's figure is an excellent one and his description agrees well with the specimen under notice. The chief characteristics of the species are its silvery grey colour and the narrow median dark band of the forewings. Evidently the species is rare, but as Dr. Turner's capture was in perfect condition it is probable that it may be an autumn subalpine form and on the wing at a date when collectors are not usually in its haunts.

### *Dasypodia cymatodes* Guen.

In the *New Zealand Journal of Science and Technology*, vol 7, p. 367, Miss A. Castle records this well known Australian species as taken at Whangamarino and Whangarei. In January 1927, Mr. D. D. Milligan sent the writer two examples from Leigh, North Auckland, and in February Mr. C. Stalker secured a fine specimen at Nelson. As the insect is a large one (only slightly smaller than *D. selenophora*) it is unlikely that it would remain unnoticed for any considerable period; the species is therefore in all probability a quite recent introduction from Australia.

### GEOMETRIDAE.

#### *Dasyuris austrina* n. sp.

♂. 30 mm. Head white densely mixed with black. Palpi ochreous-white mixed with black. Antennae greyish-black. Thorax and abdomen black mixed with whitish. Legs ochreous, strongly infuscated, tarsi annulated with ochreous. Forewings strongly arched at base, apex obtuse, termen slightly rounded, oblique; greyish-fuscous, densely irrorated with bluish-white on basal  $\frac{2}{3}$ ; an indistinct irregular basal line; first line at  $\frac{1}{3}$ , irregularly dentate, fuscous; a round fuscous discal spot; second line at  $\frac{2}{3}$ , fairly broad, fuscous, indented above and below middle, posteriorly margined with whitish; an obscure thin irregular subterminal white line: fringes white barred with fuscous and with a fuscous basal line. Hindwings coloured as forewings, all lines except basal present, but straighter than in fore-

wings: fringes whitish mixed with fuscous, clear white round apex. Undersides ochreous-white with four thin lines and narrow terminal margin black.

Resembles the much larger *D. hectori* Walk. but paler in colour and with the undersides very different.

Bold Peak, in January. I have a female of what is probably the same species from The Hump, Southland, but as the specimen differs in some details and the localities are far apart, I have not included it among the type material. Holotype and slide of type genitalia in coll. A. Philpott.

***Lythria regilla* n. sp.**

♂ ♀. 24-28 mm. Head and thorax bright yellow mixed with black, round eye whitish. Palpi yellow, terminal segment mixed with black and white. Antennae blackish-fuscous, in female mixed with yellow, pectinations in ♂ 3. Abdomen black mixed with yellow, segmental divisions white. Legs whitish-ochreous mixed with fuscous, tarsi annulated with whitish-ochreous. Forewings triangular, costa straight, apex rounded, termen rounded, more angular in ♀; banded alternately with orange-yellow and black; a small basal area orange-yellow with some white and black scales; an almost straight narrow black fascia; a narrow orange-yellow fascia, usually whitish on lower part; a rather broader and more irregular black fascia, usually dilated on dorsum; a similar fascia of orange-yellow, white on dorsum but without dilation; a rather irregular black fascia, its upper half divided and the division filled with orange-yellow; an orange-yellow fascia of about equal breadth; a black fascia, sharply elbowed above middle and thence sinuate to dorsum, followed by a similar orange-yellow fascia; area between this and termen black, but including a subterminal dentate orange-yellow line frequently broken up into a chain of spots, the central spot being always more or less dash-like in shape and sometimes connected with the preceding yellow fascia: fringes black, outer half barred with yellowish-white. Hindwings orange-yellow; markings black; a thin nearly straight fascia at  $\frac{1}{4}$ ; a more prominent angled fascia at  $\frac{1}{2}$ ; a broad interrupted irregular fascia at  $\frac{3}{4}$ ; termen broadly black with a tendency to dentation of the inner margin; fringes as in forewings. Undersides bright yellow with the black fasciae of the upper surfaces imperfectly reproduced.

A very striking species, frequently confused with the less handsome *L. perornata* Walk.

Dun Mountain, Mount Starveall, Cobb Valley, Mount Arthur Tableland and Mount Cedric, from December to February. Not very common but probably to be found in all subalpine localities in the Nelson Province. Holotype (♂), allotype (♀) and a series of paratypes in coll. Cawthron Institute.

SELIDOSEMIDAE.

***Selidosema flava* (Warr.), Nov. Zool., 3, 406.**

As far as I am aware, this species has not been recognized or referred to by any New Zealand entomologist since its description

about fifty years ago, but in January of this year (1927) Mr. E. S. Gourlay captured two males at Murchison, West Coast. These he kindly presented to the Cawthron Institute. As *Novitates Zoologicae* is not readily accessible to New Zealand workers I extract the description. "Forewings pale yellow, the costa and inner margin speckled with fuscous; a brown hour-glass-shaped blotch on middle of costa extending to a little below the middle; a blotch on costa before apex, with a smaller one below it, and another on hindmargin below apex; a line of fuscous dashes along hindmargin between the veins; fringe yellow. Hindwings wholly yellow. Undersides dull yellow, the forewings suffused with brownish. Face and palpi yellowish, tinged with fuscous; antennae brown; thorax and abdomen yellow. Expanse of wings, 38 mm.

"One male from Greymouth, New Zealand."

For a copy of the above description I am much indebted to Mr. A. J. Nicholson, Lecturer in Entomology at the University of Sydney.

**S. melinata** Feld., *Reis Nov.*, pl. 129, 9.

A female of this species agreeing well with Felder's figure was taken at Nelson on 15th February, 1926, by Mr. W. Heighway. A comparison of this example with *indistincta* Butl. bears out Prout's conclusion as expressed in *Trans. N.Z. Inst.*, 58, 79.

PHYCITIDAE.

**Ephestia elutella** Hb.

A specimen of this well known semidomestic species was taken by Dr. A. J. Turner in Christchurch. Its range covers practically the Northern Hemisphere, and as it feeds on various articles of human consumption, such as biscuits, figs, etc., its introduction to this country was sooner or later to be expected, more especially as it had already gained a footing in Australia.

CRAMBIDAE.

**Tauroscopa howesi** n. sp.

♂. 23 mm. Head and palpi black mixed with tawny. Antennae black mixed with whitish, clothed with ochreous pubescence. Thorax and abdomen black. Legs black mixed with ochreous. Forewings short, costa moderately arched at base, apex rounded, termen evenly rounded, oblique; fuscous-black with a few brown scales; lines white; first line rather broad, irregularly dentate, evenly curved from  $\frac{1}{2}$  costa to two-fifths dorsum; second line less distinct, indented beneath costa, thence sinuate to tornus; fringes fuscous-grey mixed with white; a thin dark subbasal line. Hindwings fuscous: fringes as in forewings.

Nearest *T. gorgopis* Meyr. but the second line is altogether different.

Obelisk Range, Central Otago, in February. A single male taken by Mr. G. Howes when on a collecting trip with the late Augustus Hamilton in 1912. Holotype in coll. A. Philpott.

## PYRAUSTIDAE.

**Scoparia legionaria** n. sp.

♂ ♀. 27-33 mm. Head, palpi and thorax white mixed with fuscous. Antennae brown, minutely ciliated. Abdomen ochreous-white. Legs whitish mixed with fuscous, anterior pair mostly fuscous, tarsi narrowly annulated with whitish. Forewings elongate, costa slightly arched, apex obtuse, termen almost straight, little oblique; white, densely irrorated with fuscous; a small blackish spot on costa at base, margined beneath with white; first line from costa at  $\frac{1}{4}$  to dorsum at  $\frac{1}{3}$ , white, posteriorly suffusedly margined with fuscous, often very obscure; orbicular oval, white, ringed with fuscous; claviform dot-like, fuscous, obliquely beyond orbicular, frequently absent; reniform incomplete, indicated by some fuscous marks, interior usually more or less ochreous; second line dentate, deeply indented beneath costa, white, anteriorly margined with fuscous; subterminal line an obscure whitish shade; a terminal series of black spots: fringes white, basally barred with fuscous and with a subapical fuscous line. Hindwings and fringes ochreous-whitish.

Approaching *S. petrina* Meyr., but a larger and less distinctly marked insect. The female is smaller and lighter in colour than the male.

Mount Arthur Tableland and Gordon's Pyramid at about 4,000 feet. Common in February. Holotype (♂), allotype (♀) and a series of paratypes in coll. Cawthron Institute.

**Scoparia turneri** n. sp.

♂. 18-21 mm. Head brown mixed with white. Palpi rather long, internally and beneath white. Antennae brown, serrulate, cilia-tions in ♂  $\frac{1}{2}$ . Thorax brown. Abdomen ochreous-grey. Legs brown, posterior pair greyish with tarsi faintly annulated with white. Forewings long, very narrow at base, evenly widened to termen, costa straight, apex round-pointed, termen slightly sinuate, very oblique; brown, irrorated with fuscous and white; first line curved, very indistinct, white, obscurely and suffusedly margined posteriorly with brown; orbicular and claviform dot-like or obsolete; reniform an irregular whitish mark incompletely margined with fuscous; second line prominent, almost straight, parallel to termen; white; subterminal line broad, suffused, obscure, white; a terminal series of black dots: fringes greyish-brown with dark basal line. Hindwings and fringes ochreous-grey.

The wing contour is similar to that of *S. exilis* Knaggs. The straight oblique second line is a good distinguishing character.

Arthur's Pass, in February. Four males taken by Dr. A. J. Turner who very kindly presented the specimens, together with several other novelties, to the Cawthron Institute. Holotype (♂) and three paratypes in coll. Cawthron Institute.

**Scoparia parca** n. sp.

♂ ♀. 19-24. Head and palpi fuscous mixed with white. Thorax dark purplish-fuscous. Antennae brown, minutely ciliated. Abdomen greyish-fuscous. Legs ochreous-whitish, more or less infuscated, pos-

terior pair ochreous-white with dark fuscous spurs. Forewings moderate, costa almost straight, apex obtuse, termen slightly sinuate, oblique; greyish-fuscous; sometimes darker between first and second lines; first line very obscure or absent, posteriorly dark margined, evenly curved; orbicular and claviform included in dark margining of first line; reniform an indistinct blotch, blackish with clear white spot in lower part; second line very obscure, thin, whitish, indented beneath costa, thence strongly incurved and reaching dorsum at  $\frac{2}{3}$ ; veins obscurely and interruptedly outlined in black; a subterminal series of black spots: fringes ochreous-whitish with basal and median fuscous lines. Hindwings and fringes pale whitish-grey.

An obscure species, but not close to any other.

Mount Grey and Hoon Hay, in November. Two males and one female taken by Messrs. S. Lindsay and W. Heighway. Holotype (♂) in coll. Cawthron Institute, allotype (♀) and one paratype in coll. S. Lindsay.

***Scoparia pallidula* n. sp.**

♂ ♀. 18 mm. Head and palpi brown mixed with white. Antennae brown, minutely ciliated. Abdomen brownish-ochreous. Legs brown mixed with ochreous-white, tarsi annulated with white. Forewings moderate, costa slightly arched, apex obtuse, termen straight, rounded beneath, oblique; white, densely irrorated with pale brownish; veins obscurely and interruptedly outlined with blackish; lines and stigmata (except reniform) obsolete; reniform obscurely X-shaped, lower fork filled with white; a terminal series of black spots; fringes grey with obscure dark basal shade. Hindwings and fringes grey with slight ochreous tinge.

Somewhat resembling *S. deltophora* Meyr., but a smaller species and with greyer forewings.

Mount Grey, in December and January. A good series taken by Messrs. Lindsay and Heighway in the years 1921 and 1924. Holotype (♂) in coll. Cawthron Institute; allotype (♀) and a good series of paratypes in coll. S. Lindsay.

TORTRICIDAE.

***Eurythecta fraudulenta* n. sp.**

♂. 11-14 mm. Head and palpi dark brown mixed with ferruginous or red. Antennae brown mixed with grey, ciliations over one. Thorax dark brown, sometimes mixed with reddish. Abdomen and legs dark brown. Forewings, costa strongly arched at base, apex rectangular, termen moderately rounded, slightly oblique; dark slaty brown strigulated throughout with ferruginous or red; fringes slate colour, basal half reddish. Hindwings greyish-fuscous: fringes greyish-fuscous with dark basal line.

♀. Head and thorax brown, ochreous or ferruginous. Forewings usually brown mixed with yellow, ferruginous or reddish; margin of basal patch very oblique, reaching dorsum at about  $\frac{1}{2}$ ; a broad, fairly even paler fascia following basal patch, usually lead-coloured, sometimes whitish, frequently obscure; a short white outwardly oblique fascia from costa at  $\frac{2}{3}$ , frequently bent at middle and

continued in lead-colour to before tornus, sometimes forming part of a subtriangular patch on costa before apex: fringes a mixture of the wing colours. Hindwings fuscous: fringes fuscous with dark basal line, round apex ochreous-whitish.

Superficially very similar to *Epichorista emphanes* Meyr. The female is extremely variable, one example having the first and second fasciae united and forming a broad white band across the wing.

Gordon's Pyramid and Mount Arthur Tableland, in February and March. A good series taken at about 4,000 feet. Holotype (♂), allotype (♀) and a series of paratypes in coll. Cawthron Institute.

#### GELECHIIDAE.

##### *Anisoplaca fraxinea* n. sp.

♂ ♀. 19-21 mm. Head and thorax ochreous-white mixed with drab, sides of face black. Palpi ochreous-white, basal  $\frac{2}{3}$  of second segment black, basal and median fuscous rings on terminal segment. Antennae ochreous-white mixed with fuscous, in male serrulate, cilia-tions  $\frac{1}{2}$ . Abdomen whitish-ochreous mixed with fuscous. Legs ochreous, strongly infuscated, tarsi annulated with ochreous. Forewings elongate, costa moderately arched, apex round-pointed, termen rounded, oblique; whitish-ochreous densely irrorated with brownish-ochreous and strigulated with fuscous; costa with black spot at base; costal edge dotted with blackish-fuscous throughout; first discal a blackish dot ringed with whitish; other stigmata obscure or absent; termen margined with blackish-fuscous: fringes ochreous with median fuscous line. Hindwings fuscous-grey: fringes ochreous with obscure dark basal shade.

Superficially nearest to *A. achyrotia* Meyr.

Nelson and Flora River, in March. Dr. Turner has also taken it at Arthurs Pass in February. Holotype (♂), allotype (♀), slide of male genitalia and paratypes in coll. Cawthron Institute.

##### *Lecithocera micromela* Low. *Trans. Roy. Soc. S. Aus.*, 21, 55.

Of this Australian species Dr. Turner took examples at Rotorua. These he has presented to the Cawthron Institute, together with Australian specimens of the same insect. Having regard to the central position of the locality it does not seem probable that the species is an accidental introduction to New Zealand. The insect is not a striking one, being only about 12 mm. in expanse of wing. The head, thorax and forewings are sooty black, the antennae and palpi ochreous and the hindwings fuscous.

##### *Stomopteryx columbina* n. sp.

This species is described, under the name *S. simplicella* (Walk.) in *Trans. N.Z. Inst.*, 55, 666.\* Having, through the kindness of Dr. A. J. Turner, received Australian specimens of Walker's species I

\*I take this opportunity of correcting an error in the legend of the figures at the above reference. By a transposition of drawings the genitalia of *Gelechia neglecta* Philp. are represented as those of *Stomopteryx simplicella* Walk.

have been able to compare the male genitalia of the two forms, and I here give figures of the harpes, which are of quite definite distinctness. Apart, however, from the structural characters there appears to be a colour character of some value in separating the two forms, the white mark on the forewings at  $\frac{3}{4}$  being reduced to a mere spot in *columbina* while it often forms an almost complete fascia in *simplicella*.

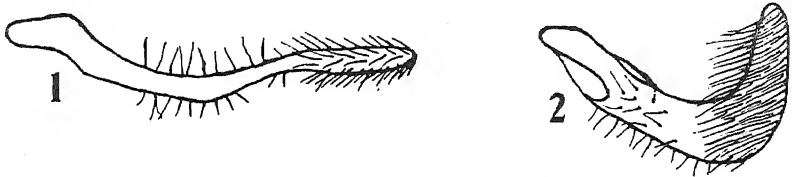


FIG. 1.—*Stomopteryx simplicella* Walk. Harpe, inner view.

FIG. 2.—*S. columbina* n. sp. Harpe, inner view.

#### OECOPHORIDAE.

##### **Borkhausenia decora** n. sp.

♂. 9-11 mm. Head, palpi, thorax and abdomen purplish-black. Antennae purplish-black, ciliations  $\frac{3}{4}$ . Legs purplish-fuscous, tarsi annulated with ochreous. Forewings, costa slightly arched, apex broadly rounded, termen rounded, strongly oblique; bright yellow to orange; markings shining silvery; an outwardly oblique fascia from  $\frac{1}{4}$ , broadly margined with black, reaching beyond fold; an almost straight fascia from middle of costa to before dorsum; a triangular fascia from costa at  $\frac{3}{4}$  reaching half across wing; a narrow subterminal fascia parallel to termen; the last three fasciae with a few black scales on margins: fringes dark fuscous, base orange. Hindwings dark fuscous: fringes dark fuscous with darker basal line.

Near *B. compsogramma* Meyr. and *B. chrysogramma* Meyr., but in both of these species the first fascia reaches the dorsum.

Lake Rotoroa, in February. Three males secured. Holotype and paratypes in coll. Cawthron Institute.

##### **Borkhausenia latens** n. sp.

♂. 11 mm. Head and thorax greyish-ochreous mixed with fuscous. Papi ochreous-white, base, subapical ring on second segment and a subbasal ring on terminal segment, fuscous. Antennae fuscous mixed with ochreous, minutely ciliated. Abdomen whitish-ochreous, mixed with fuscous except on basal segments. Legs whitish-ochreous, anterior tibiae and tarsi broadly banded with fuscous. Forewings, costa moderately arched, apex broadly rounded, termen rounded, oblique; whitish-ochreous with scattered brown scales; markings fuscous-blackish, suffused; a thick oblique fascia from costa at base to fold, where it includes plical spot; first discal spot obliquely above plical; a broadly suffused irregular fascia from costa at  $\frac{1}{2}$  to tornus; a short fascia from costa at  $\frac{3}{4}$ : fringes whitish-ochreous mixed with fuscous. Hindwings shining greyish-white: fringes whitish-ochreous.

Resembling the larger species *B. plagiatelylla* Walk. in some respects, but there are many differences of markings.

Rotorua, in February. A single male taken by Dr. A. J. Turner. Holotype in coll. Cawthron Institute.

***Borkhausenia clarkei* n. sp.**

♂. 15-16 mm. Head and antennae greyish-fuscous, ciliations in ♂  $\frac{3}{4}$ . Palpi fuscous, second segment mixed with white within. Abdomen fuscous-grey. Legs, anterior pair fuscous, middle pair fuscous with tibiae and tarsi banded with whitish, posterior pair fuscous-grey. Forewings moderate, costa well arched, apex rounded, termen rounded, oblique; white, irrorated with dark fuscous; stigmata blackish; plical large, obliquely before first discal, coalescing with dark patch on dorsum; irroration tending to form blotches on costa at base,  $\frac{1}{3}$ ,  $\frac{1}{2}$  and  $\frac{2}{3}$ ; apical blotch sending an obscure line to tornus, where it forms a tornal blotch: fringes whitish-grey mixed with fuscous. Hindwings and fringes fuscous-grey.

Nearest *B. seclusa* Philp., but with more contrasted colouring.

Waikaraka Valley and Kauri Gully, Auckland, in January. Discovered by Mr. C. E. Clarke, who has asked me to describe the species. A male from each locality. Holotype in coll. C. E. Clarke and paratype in coll. Cawthron Institute.

***Gymnobathra primaria* n. sp.**

♂. 19-21 mm. Head ochreous. Palpi and thorax ochreous mixed with fuscous. Antennae ochreous mixed with fuscous, finely serrulate, ciliations 1. Abdomen brassy, anal tuft ochreous. Legs whitish-ochreous, more or less infuscated, anterior pairs almost wholly fuscous. Forewings, costa well arched, apex obtuse, termen rounded, oblique; greyish-ochreous sprinkled with fuscous-black; markings fuscous-black; a small spot on base of costa continued for a short distance along costal edge; first discal spot fairly large; plical obliquely beyond first discal, small; second discal as large as first discal, usually slightly elongated in direction of tornus; five or six spots on costa between  $\frac{1}{2}$  and apex: fringes greyish-ochreous with obscure subbasal fuscous line. Hindwings whitish-grey, infuscated round termen and dorsum: fringes ochreous-grey with dark basal line.

This and the two following species are superficially very much alike. The present species is the largest of the three. The males can be easily separated by the characters of the genitalia which can usually be made out without dissection.

Mount Arthur Tableland (4,500 feet), Flora River (3,000 feet), and Aniseed Valley, in December and February. Four males. Holotype and paratypes in coll. Cawthron Institute.

***Gymnobathra levigata* n. sp.**

♂ ♀. 14-17 mm. Head and thorax ochreous. Palpi ochreous mixed with fuscous, second segment not much thickened with scales and tapering smoothly into terminal segment. Antennae ochreous annulated with fuscous, ciliations about 1. Abdomen brassy, segmental divisions whitish. Legs whitish-ochreous mixed with fuscous. Forewings, costa moderately arched, apex pointed, termen slightly rounded, oblique; pale ochreous-white, thickly irrorated with ochreous and sprinkled with fuscous; female more brownish; stigmata fuscous-

black, often obscure; first discal round, obliquely before plical which is usually smaller, but sometimes larger, than first discal; second discal largest, usually curved, sometimes double; a minute spot on costa at  $\frac{2}{3}$ , not always present: fringes ochreous-whitish with dark subbasal shade. Hindwings shining white, slightly ochreous towards apex.

Easily distinguished from its allies by the form of the labial palpi.

Dun Mountain and Mount Arthur Tableland, in November and December. Fairly common at elevations of from 3,000 to 4,500 feet. Holotype (♂), allotype (♀) and several paratypes in coll. Cawthron Institute.

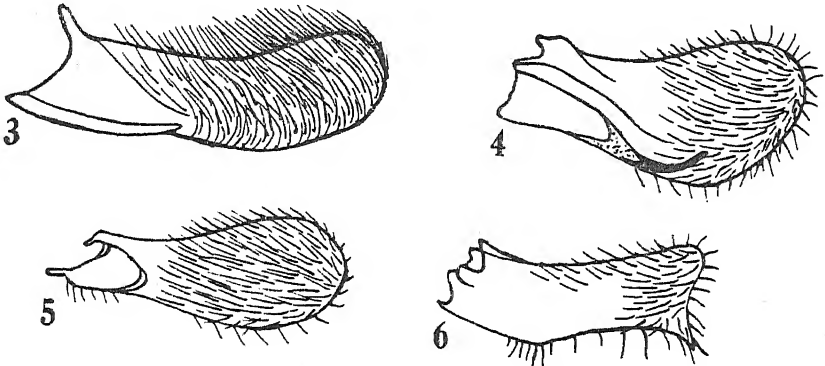


FIG. 3.—*Gymnobathra inaequata* n. sp. Harpe, inner view.

FIG. 4.—*G. primaria* n. sp. Harpe, inner view.

FIG. 5.—*G. levigata* n. sp. Harpe, inner view.

FIG. 6.—*G. calliploca* Meyr. Harpe, inner view.

### *Gymnobathra inaequata* n. sp.

♂ ♀. 17-19. Head and thorax pale ochreous, base of tegulae fuscous. Palpi, second segment thickened with appressed scales, apex broad and truncate, ochreous; second segment outwardly fuscous. Antennae ochreous, ciliations in ♂ about 1. Abdomen brassy, segmental divisions whitish, anal tuft ochreous. Legs ochreous, densely irrorated with fuscous, especially anterior pairs. Forewings, costa moderately arched, apex blunt-pointed, termen rounded, oblique; whitish-ochreous (in ♀ browner) sprinkled with blackish-fuscous; markings blackish-fuscous; a small area at costa at base; first discal rather irregular, obliquely before plical which is roundish and as large as, or larger than, first discal; second discal smaller, dot-like or transversely linear; four or five dots on costa between  $\frac{1}{2}$  and apex, apical ones usually very obscure: fringes whitish-ochreous with some fuscous scales. Hindwings shining whitish: fringes ochreous tinged.

Superficially extremely like the preceding species, but easily separated by the difference in the palpi. In *Trans. N.Z. Inst.*, 57, 719, I have figured the male genitalia of this species as those of *B. calliploca* and in order to avoid confusion I here supply figures of the four allied species.

Dun Mountain, Flora River and Cobb Valley, in November and December. As at present known, this species seems to occur at lower altitudes than *B. levigata*, 3,000 feet being the highest elevation recorded. Holotype (♂), allotype (♀) and a series of paratypes in coll. Cawthron Institute.

**Trachypepla metallifera** n. sp.

♂. 11-13 mm. Head fuscous mixed with ferruginous. Antennae fuscous annulated with yellow, ciliations in ♂ 2½. Palpi dark fuscous mixed with yellow. Thorax fuscous mixed with ferruginous and yellow. Abdomen dark bronzy-fuscous. Legs fuscous, tarsi annulated with ochreous. Forewings, costa slightly arched, apex round-pointed, termen rounded, oblique; ferruginous mixed with yellow and with some fuscous on basal half; scale tufts more or less blackish; a rather broad silvery-white median fascia, outwardly oblique from costa; a pale yellowish patch at apex, from which issues a thin terminal line: fringes ferruginous-yellow with fuscous tips. Hindwings and fringes dark bronzy fuscous.

Waimarino and Raurimu, in January. Two males secured by Mr. C. E. Clarke. What appears to be the same species, though less bright in colour, has been taken in the South Island by the late Mr. C. C. Fenwick at Eglinton Valley, and by the writer at Wairaurahiri and Goulard Downs, Nelson. Holotype (♂) in coll. C. E. Clarke and paratype in coll. Cawthron Institute.

**Proteodes varia** n. sp.

♂. 19-20 mm. Head and palpi whitish mixed with fuscous. Antennae greyish-fuscous. Thorax fuscous mixed with grey and whitish. Abdomen grey. Legs whitish, all tibiae and tarsi strongly infuscated and annulated with ochreous-white. Forewings, costa strongly arched, apex rectangular, termen almost straight, rounded beneath, not oblique: white, densely irrorated with grey and strigulated with fuscous, the strigulations tending to form chains of spots; a large more or less round blackish-fuscous spot in disc at ¼ with an irregular bar of the same colour beneath it on fold; an irregular blackish-fuscous spot in disc at ⅔; between these two spots a whitish suffusion: an obscure series of blackish marks round termen: fringes grey with dark subbasal line. Hindwings and fringes pale grey.

Near *P. melographa* Meyr. but differing in several details. One specimen has the discal spot reddish.

Nelson, in February, March and April. Four males. Holotype and paratypes in coll. Cawthron Institute.

**Euprionocera** (?) **notabilis** n. sp.

♀. 34-37. mm. Head whitish-ochreous mixed with brown. Palpi long, curved, second segment thickened with appressed scales, terminal thin, acute, whitish-ochreous mixed with ochreous. Antennae whitish-ochreous mixed with brownish. Thorax whitish-ochreous with an obscure brown median stripe and a pair of more prominent brown lateral stripes. Abdomen ochreous-white. Legs ochreous-white, anterior tarsi broadly banded with brown. Forewings long, narrow, costa moderately arched at base, apex acute, termen sinuate, oblique;

whitish-ochreous; markings brown; a fairly broad but indistinct median stripe from base to apex; a very obscure narrow streak along dorsum to near tornus; first discal spot minute; plical spot obsolete; second discal large, round; subterminal and terminal series of hardly perceptible dots: fringes ochreous-white. Hindwings and fringes shining ochreous-white.

This fine insect is only provisionally placed in *Euprionocera*; it does not agree in all points with that genus, but in the absence of the male it is inadvisable to erect a new genus at this juncture.

Flora River, in February and March. Two females secured after dark at about 3,000 feet. Holotype and paratype in coll. Cawthron Institute.

#### GLYPHIPTERYGIDAE.

##### *Heliostibes gregalis* n. sp.

♀. 14-16 mm. Head and thorax snuff-brown, face ochreous. Palpi ochreous, terminal segment dark fuscous. Antennae dark fuscous mixed with brown. Abdomen dark fuscous, copper tinged, segmental divisions ochreous. Legs ochreous mixed with purplish-fuscous, anterior tibiae and tarsi almost entirely purplish-fuscous. Forewings, costa slightly arched, apex rectangular, termen almost straight, slightly oblique; snuff-brown mixed with white in disc; an obscure rather broad white subterminal line, indented beneath costa: fringes dark fuscous mixed with brown, tips brown. Hindwings blackish-fuscous, paler towards base: fringes greyish-fuscous with dark basal line, round apex ochreous.

The almost unicolourous forewings at once distinguish the species from the other members of the genus.

Russell, Bay of Islands. Three females bred from larvae feeding gregariously on *Leptospermum* in the manner of *H. atychioides*. The material was sent to the Cawthron Institute by Mr. R. Stone Florance as a pest on manuka shrubs and was thought to be the well known *H. atychioides*; the rearing out of the larvae, however, resulted in the discovery of the new species. Holotype and paratypes in coll. Cawthron Institute.

##### *Glyphipteryx similis* n. sp.

♂. 12-13 mm. Head, antennae and thorax bronzy brown. Palpi white, with four bands and apex of terminal segment beneath, black, the black turning to bronzy brown above. Abdomen bronzy brown, apex ochreous. Legs bronzy brown, tarsi annulated with whitish. Forewings, costa moderately arched, apex broadly rounded, termen with indentation above middle, oblique; bronzy brown, paler on apical half; a broad white fascia from dorsum near base, narrowed apically and reaching beyond fold; a narrower white fascia from costa before  $\frac{1}{3}$  reaching to fold; a similar fascia crossing wing a little beyond this, slightly excurved, rather dilated on dorsum, in disc violet-purplish-metallic; a similar but straighter and narrower fascia following this; three short fasciae between this and apex, white on costa, violet-purplish-metallic beneath, the second reaching indentation on termen; a black apical spot; a black blotch along lower half of termen containing five (sometimes, by coalescence, a smaller number) golden-violet-metallic spots; above this blotch two or three blackish lines:

fringes whitish, basally broadly fuscous except at indentation. Hindwings and fringes greyish-fuscous.

Superficially like a pale *G. zomeuta* Meyr., but with narrower wings than that species.

Mount Arthur Tableland and Gordon's Pyramid, January to March. Eight males taken at about 4,500 feet. Holotype and paratypes in coll. Cawthron Institute.

#### COLEOPHORIDAE.

##### *Bactrachedra litterata* n. sp.

♀. 10-11 mm. Head and thorax whitish-ochreous. Palpi whitish-ochreous, marked with brown outwardly. Antennae ochreous annulated with brown. Legs whitish-ochreous, anterior pair infuscated, tarsi faintly annulated with paler. Forewings whitish-ochreous, darker apically, round apex black: fringes greyish-fuscous, round apex ochreous. Hindwings greyish-fuscous.

The black apex of forewings is a sufficient distinguishing character.

Greymouth, in February. Dr. A. J. Turner secured two females and a damaged male. Holotype (♀) and paratype in coll. Cawthron Institute.

#### TINEIDAE.

##### *Tinea dividua* n. sp.

♂. 17-18 mm. Head ochreous. Palpi ochreous mixed with fuscous. Antennae fuscous mixed with ochreous, ciliations 1. Thorax and abdomen dark fuscous mixed with ochreous. Legs dark fuscous mixed with ochreous, tarsi narrowly annulated with ochreous. Forewings, costa moderately arched, apex pointed, termen almost straight, strongly oblique; bright brown with scattered whitish and fuscous scales; costal margin on apical half more or less whitish; a broad stripe of whitish along dorsum to tornus where it is ochreous tinged; upper margin of this stripe interrupted at middle by a blackish-brown spot: fringes brown mixed with ochreous. Hindwings dark purplish-fuscous: fringes fuscous.

The pale dorsal area with the included dark spot is a good specific character.

Flora River and Gordons Pyramid, in January. Two males Holotype, paratype and slide of type genitalia in coll. Cawthron Institute.

##### *Mallobathra obscura* n. sp.

♂. 11-14 mm. Head, palpi and thorax dark brown. Antennae dark brown, ciliations in ♂ 3. Legs brown. Forewings, costa moderately arched, apex rounded, termen rounded, oblique; rather bright brown closely strigulated with dark fuscous: fringes brown, tips greyish. Hindwings and fringes dark purplish-fuscous.

Extremely like *M. homalopa* Meyr. but slightly brighter in colour and proportionately broader-winged. The differences in the male genitalia are definite and sufficient.

Southland. Fairly common in October. Holotype and paratypes in coll. A. Philpott.

## Notes on *Isonomeutis aumaropa* Meyr. (Lepidoptera).

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera,  
Cawthron Institute, Nelson.

[Read before the Nelson Philosophical Society, 26th October, 1927;  
received by Editor, 28th October, 1927; issued separately,  
14th February, 1928.]

THE genus *Isonomeutis* was erected by Meyrick in 1887 for the reception of a peculiar little Pyralid-like species taken at Whangarei. Since then the moth has been found at Wellington and Nelson, the probability being that it occurs in suitable localities throughout the North Island and the northern portion of the South. The larva is said by Hudson to live under the bark-flakes of the matai (*Podocarpus spicata*), feeding on the softer growing portion and subsequently forming a tough pupal cocoon of silk covered with fragments of bark.

In the original description Meyrick placed the species in the Conchylidae (now known as the Phalonidae), but in his "Revision of the classification of the New Zealand Tortricina" (*Trans. N.Z. Inst.*, 43, 78) he states that after further study he has concluded that "*Isonomeutis* is not correctly referable to this group" (the Tortricoidea) and that he has removed it to the Plutellidae. In 1923, however, the genus is referred back to the Tortricoidea and placed, with a second species, *I. restincta*, in the family Copromorphidae, which includes one other New Zealand species, *Phycomorpha metachrysa* Meyr.

Hudson has given coloured figures of the female moth and the larva in his *Manual of New Zealand Entomology*, pl. 13, figs. 2 and 2A, but, as far as I am aware, no structural figures have yet been published. It may be useful, therefore, to present a series of these and to comment on their characteristics with a view to more definitely fixing the systematic position of this interesting and puzzling genus.

### THE VENATION.

It will be noted that in the anal area of the forewing there is only one vein, and that it is not forked basally. This vein may be called 2A or 2A+1A. The anal furrow is hardly marked at all, there being only the merest indication of it near the base. Culb is rather remote from the angle, but Cula, the branches of M, and R2, R4, and R5 are almost equidistant at their bases. R2 rises from the cell slightly basad of Culb, and R1 at about middle of cell. Sc is in a normal position, pursuing a course about halfway between the costal margin and the radius. No part of M is present within the cell. In the hindwing 3A is present and 2A and 1A are coincident except for a short distance at the base. The anal fold is well marked but does not contain any vein. Culb is fairly remote from the angle of cell; Cula and M3 are connate; M1 rises from about the middle of the oblique discocellulars with M2 a little nearer to it than to M3;

R is remote from M1 and proceeds straight from the upper angle of cell, reaching margin at apex. Sc is basally connate with R, gradually diverging from the lower vein. The course of the basal portion of M is weakly marked within the cell.

In studying the venation there are three points to which attention must be directed, namely, the reduction of the veins in the anal

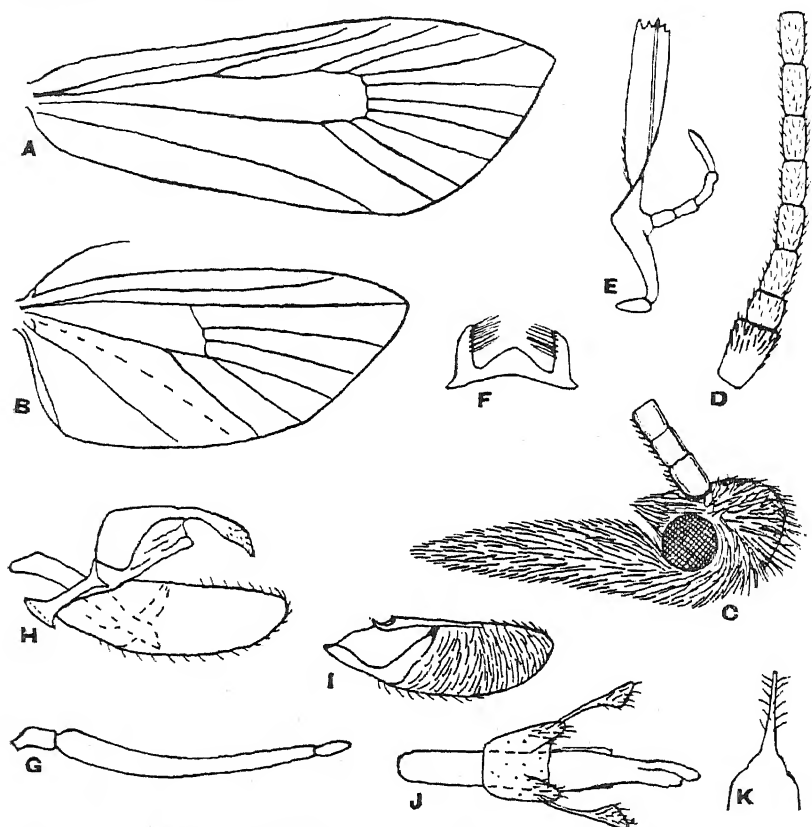


FIG. 1.—*Isonomeutis aumaropa* Meyr. A, forewing. B, hindwing. C, head, lateral view. D, antenna, basal portion. E, maxilla. F, labrum with pilifers. G, labial palp, denuded. H, male genitalia, lateral view. I, harpe, inner view. J, aedeagus and juxta. K, uncus, dorsal view.

area, the basal position of those veins which rise from the end of the cell, and the fact that there are no stalked veins. In the Tortricodea the main anal vein is normally strongly forked basally, and there is at least an apical remnant of the vein occupying the anal furrow. In the hindwing the almost complete coincidence of the first and second anal veins should be noted, also the basal connection of Cula and M3.

#### THE HEAD, MOUTH-PARTS, ETC.

The antennae of the male are filiform and pubescent, with 38 segments in the flagellum. Palpi long, porrected, pointed, rough-

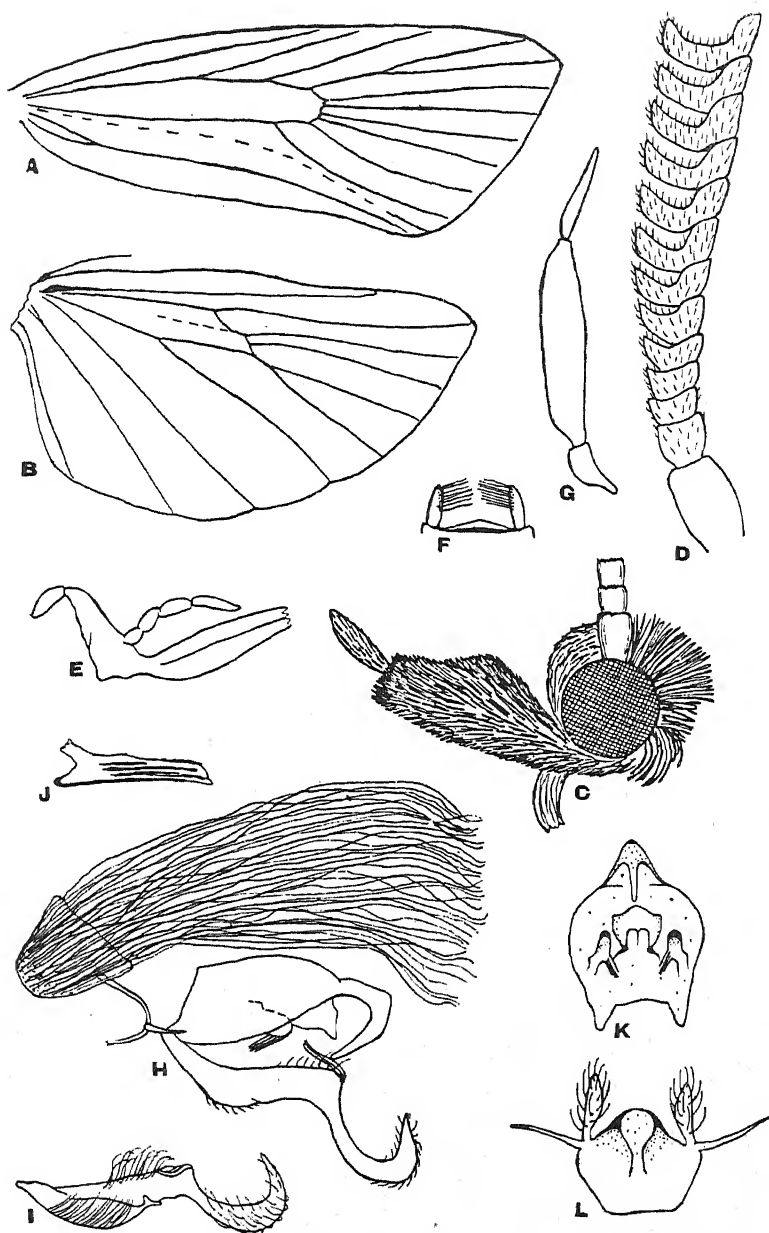


FIG. 2.—*Phycomorpha metachrysa* Meyr. A, forewing. B, hindwing. C, head, lateral view. D, antenna, basal portion. E, maxilla. F, labrum with pilifers. G, labial palp, denuded. H, male genitalia, lateral view, with left hair-sac removed and right hair-sac displaced. I, harpe, inner view. J, aedeagus. K, tegumen, ventral view. L, juxta.

sealed above and beneath, with terminal segment hidden. Haustellum developed; maxillary palpi reduced, 4-segmented. Thorax without crests; posterior tibiae smooth.

#### MALE GENITALIA.

Tegumen broad; uncus long, curved, laterally compressed. Gnathos absent. Vinculum moderate, arms rather broad, without saccus. Aedeagus moderate, apex irregular. Juxta a shield, with pair of small lobes and weak lateral processes attached to small transtilla. Harpes broad, entire, with inner transverse lobe near base and small transtilla.

We are now in a position to compare the characters of *Isonomeutis* with *Phycomorpha*, an undoubted genus of the Copromorphidae and in fact, differing only from the type genus in the stalking of veins R3 and R4. These differences may be tabulated as under.

	<i>Isonomeutis.</i>	<i>Phycomorpha.</i>
Forewing,		
1A	Not forked basally.	Strongly forked basally.
Culb. M3 and M2	Not approximated at base.	Approximated at base.
Culb to R3	Equidistant at point of origin.	Unequally spaced at origin.
Hindwing,		
Cula and M3	Connate.	Short-stalked.
M2	Not approximated to M3	Approximated to M3.
Pectinations	Not present.	Dense pectinations on bases of M, Cu2, and 1A.
Antennae	Filiform.	Strongly dentate.
Labial palp	Terminal segment concealed; second segment very long, about eight times as long as third.	Terminal segment not concealed; second segment about three times as long as third.
Head	Frons with projecting scales.	Frons without projecting scales.
Thorax	Without crest.	Slight posterior crest.
Posterior tibiae	Smooth.	Slightly roughened above.
Uncus	Not recurved.	Strongly recurved.
Gnathos	Absent.	Highly specialized.
Vinculum	Well developed.	Vestigial.
Hair sacs	Absent.	Present, large.
Harpes	Simple, broad, entire, with transverse basal lobe.	Very highly specialized, narrow, intricate, with basal lobe absent.

It will be seen at once that there are many and important differences between the two genera, and reference to the figures will render this still more apparent. Without so widening the definition of the Copromorphidae as to destroy the group's systematic value it does not seem possible to include *Isonomeutis* therein; nor is the writer prepared to refer it to any other family. Probably the best course in the present state of our knowledge is to regard this interesting genus as representing a distinct family, with considerable affinity to the Oecophoridae. In passing, attention may be called to the very close resemblance of the male genitalia of *Phycomorpha* to the Plutellid type. If considered on these characters alone, *Phycomorpha* might reasonably be referred to the Plutellidae, and there is quite probably some real relationship.

## Notes on *Nesomachilis maoricus* Tillyard, with particulars of a new sense-organ.

By J. W. EVANS, B.A.

(Communicated by Dr. R. J. Tillyard, F.R.S.)

[Read before the Nelson Philosophical Society, 28th September, 1927;  
received by Editor, 30th September, 1927; issued separately,  
14th February, 1928.]

At the suggestion of Dr. Tillyard I have been keeping some specimens of *Nesomachilis maoricus* Till. in captivity in order to determine particulars of their life-history. Some of the following points in connection with their anatomy have not, so far as I am aware, been previously described.

A full grown specimen of *N. maoricus* is 16 mm. long from the front of the head to the tip of the appendix dorsalis.

This insect though having many primitive characters, chief among which is the apterous condition, has acquired certain specializations, among them being the possession of scales; these vary in colour from black to pale brown and in reflected light appear bronze; in form they are very similar to those of Lepidoptera, though lacking cross striations.

The arrangement of the scales is interesting. They are placed more or less radially round a point in the centre of the mesothorax, (Fig. 1), those on the prothorax being directed forwards, while those on the first abdominal segment are directed backwards.

The scales are soon rubbed off, in which case the insect appears white and is very conspicuous, though when covered with scales it blends with its surroundings.

The maxillary palpi which consist of seven segments are long, and project in front of the head. (Figs. 3-5.) They are not held straight out but are bent, the terminal segment being parallel to and held directly under the basal segment. On the inside of the second segment and distally placed is found a sensory organ of unknown function, which occurs only in the male insects. (Figs. 2, 2A). This organ consists of a projecting finger-like process, which forms the roof of a round pad, also projecting. In this pad are inserted a number of thick black hairs, presumably modified scales, which form a brush almost coming in contact with the upper projection which is transversely striated. At the end of each instar the hairs are mostly rubbed off.

Somewhat similar sense-organs occur in certain Mecoptera and Diptera, *Nannochorista dipteroides* Till. being an example of the former. In this species the organ, which is found in both sexes and occurs on the third segment of the maxillary palp, medially placed, consists of a pit-like structure bearing sensillae, which are hair-like filaments and not modified scales.

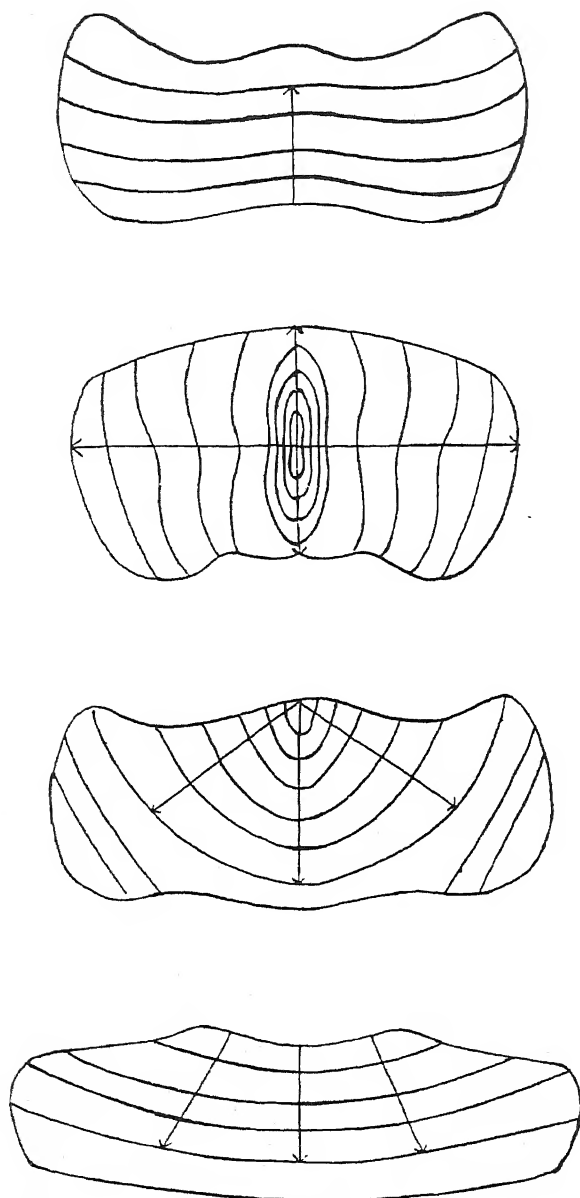


Fig. 1.

FIG. 1.—Diagram of tergites to show arrangement of scales on the thorax and first abdominal segment. The scales lie at right angles to the lines, their unattached ends pointing in the direction of the arrows. The lines do not correspond in number or position with those actually present.

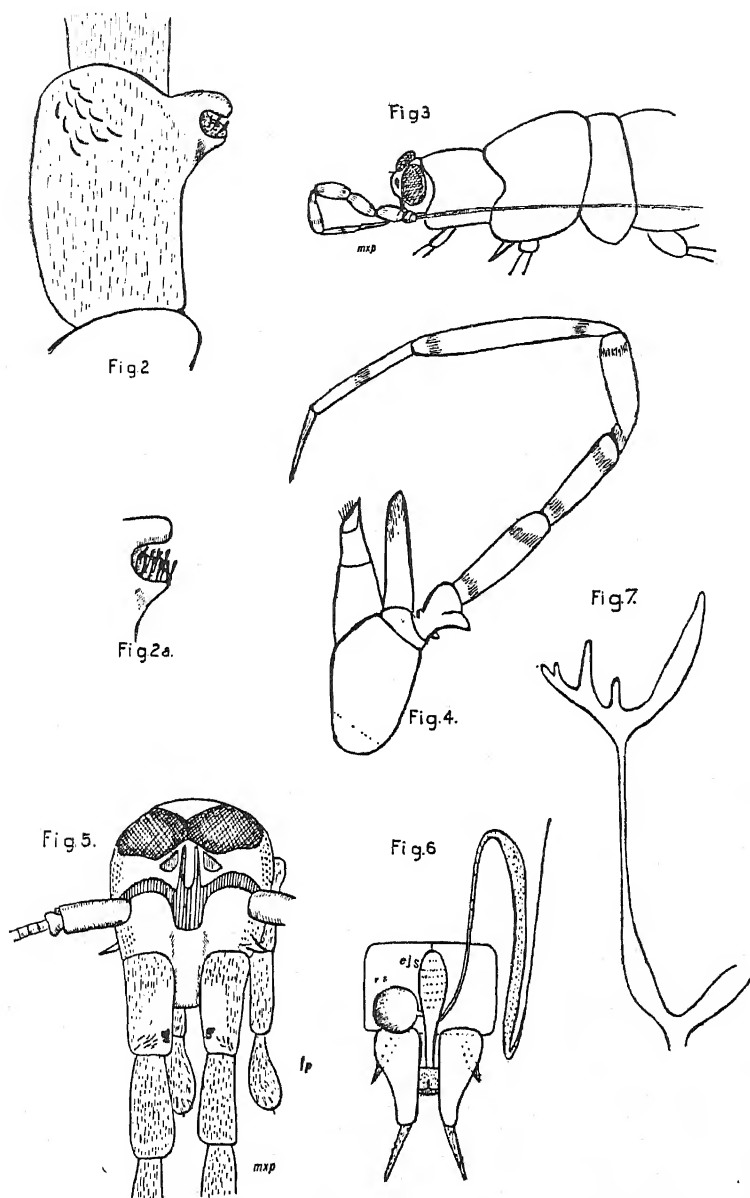


FIG. 2.—Second segment of maxillary palp of male, showing sense organ.

FIG. 2A.—Sense organ at beginning of instar.

FIG. 3.—Lateral view of insect. *mxp.* maxillary palp.

FIG. 4.—Right maxilla of female.

FIG. 5.—Front view of head of a male insect, *mxp.*, maxillary palp, *lp.*, labial palp.

FIG. 6.—Male reproductive organs. *vs.*, vesicula seminalis, *ejs.*, ejaculatory sac. (Left testis omitted.)

*Edwardsina tasmaniensis* Tonnoir. (Diptera Fam. Blepharoceridae) bears a structure similar to that described above, but the depression is more pronounced, the cuticle being invaginated and forming a flask-shaped hollow containing sensillae. This organ also occurs in both sexes and is distally placed on the third segment. A similar structure occurs also in *Simulium*.

In addition to compound eyes there are a pair of lateral ocelli on either side of a ridge bearing two sensory hairs, and a very large median ocellus which extends laterally on either side to the base of the antennae. (Fig. 5.)

The male reproductive organs differ from those of other Machilidae as figured by Grassi and Oudemans. Each testis is an elongated slender organ of which the terminal portion is filamentous, the median comparatively broad; this portion leads posteriorly into the vas deferens, which opens into the base of an elongated ejaculatory sac. A globular vesicula seminalis is also connected with the ejaculatory sac and opens into it anteriorly to its connection with the vasa deferentia. (Fig. 6.)

The ovaries, which are panöistic, are branched but not segmentally arranged, and contain orange-coloured eggs. (Fig. 7.) The figure is of an ovary of an immature female.

*Nesomachilis* is always found under stones or wood, yet in captivity it exhibits no phototropisms, being equally at home in a bright light or in the dark.

When agitated, the antennae, which are long and normally rest along the side of the body, are waved in front of the head, and the insect advances with sudden jerky movements, sometimes jumping a considerable distance off the ground.

I have to thank Dr. Tillyard and Mr. A. Tonnoir for help and advice, and Mr. E. S. Gourlay for collecting the material studied.

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## The Fresh-Water Eels of New Zealand.

By PROFESSOR JOHS. SCHMIDT, Ph.D., D.Sc., Hon. F.R.S.E.,  
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Copenhagen.

[Received by Editor through Mr. A. E. Hefford, Chief Inspector of Fisheries,  
Marine Department, 8th November, 1927; issued separately,  
14th February, 1928.]

### 1. INTRODUCTION.

AFTER having concluded my investigations into the classification and migrations of the Atlantic species of eel, researches which have occupied many years,<sup>1</sup> I have turned my attention to the eels of the Indo-Pacific region.<sup>2</sup>

The first essential here was to reduce the classification to order; for how could one hope to explain the distribution and life-history of the different species without knowledge of the characters by which the species in question could be distinguished one from another?

I had obtained excellent results in the classification of the European, American, and Japanese eels by the use of numerical characters, such as number of vertebrae, of fin rays, etc., and I therefore introduced this method in my studies of the Indo-Pacific species.

The first part of my researches here consisted in studying the material of Indo-Pacific eels to be found in most of the important museums of the world, and very liberally placed at the disposal of the Carlsberg Laboratory.

Very important results were arrived at from this preliminary work alone, not least through our being able to apply the above-mentioned method to nearly all the existing type-specimens and other specimens noted in the literature, most of which were inadequately characterized in the descriptions given. We have now X-ray photos of most of these eels from museums in different parts of the world, and have thus been enabled to determine, for instance, the number of vertebrae in every single specimen. It was, of course, out of the question to skeletonize the types, and the process of X-ray photography here represents a great advance in these researches, as the number of vertebrae is a character which cannot be dispensed with.

The comparatively few specimens from the museums, however, were not sufficient for a complete description, and I had therefore to procure a more extensive supply of material by other means.

With this end in view, I set out, in 1926, on a voyage to the Southern Pacific, visiting Australia, New Zealand, and Tahiti, and obtaining on the way great quantities of eels, sufficient for a statis-

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<sup>1</sup>Johs Schmidt: The breeding Places of the Eel (*Smithsonian Report* for 1924, Washington, 1925).

<sup>2</sup>Johs Schmidt: On the distribution of the Fresh-water Eels (*Anguilla*) throughout the World.—2. Indo-Pacific Region (*Mem. Acad. Royale Sciences et Lettres de Danemark*, 8 Ser. t. 10, No. 4, Copenhagen, 1925).

tical investigation on the lines I had previously adopted in the case of eels of Europe and America (and Japan).<sup>1</sup>

As regards the eels of Tahiti, I have published the results of my researches in the French Journal *La Nature*, No. 2765, 1927, in an article entitled "Les Anguilles de Tahiti." In this, a description is given of the three *Anguilla* species characteristic of the tropical portion of the South Pacific, viz., the two long-finned and spotted species *Anguilla mauritiana* Bennett and *Anguilla megastoma* Kaup, together with the short-finned, uniformly-coloured *Anguilla obscura* Gthr., which I was able to show was a distinct species, not identical with the *Anguilla australis* Rich. An account of the four species of eels which I have ascertained exist on the continent of Australia will, it is hoped, shortly be published elsewhere. I shall in the following pages confine myself to the eels of New Zealand. It is with great pleasure that I here acknowledge the interest with which my investigations have been regarded in New Zealand, not only in public institutions, as specially the Marine Department, with Mr. A. E. Hefford as Chief Inspector of Fisheries, but also among a number of scientists and others. I wish to acknowledge the assistance of Mr. H. G. Maurice, Secretary of the English Department of Fisheries and President of the International Council, for having introduced me to the New Zealand authorities. My thanks are also due to the following gentlemen, all of whom have helped in the work by contributing material: Mr. Gilbert Archey, Auckland; Professor W. B. Benham, F.R.S., Dunedin; Mr. T. W. Downes, Wanganui; Mr. H. Jensen, Thames; Mr. W. J. Phillips, Wellington, and Professor R. Speight, Christchurch. During my stay in New Zealand, I received much assistance from the Danish Consul at Wellington, Mr. S. A. Longuet, and in the course of my researches at Pipiriki, on the Wanganui River, I was effectively supported by Mr. Page, Pipiriki House, and the Rev. Henry Keremereta.

To all these gentlemen I beg to offer my best thanks. I have also to thank Mr. H. Luebbert, Director of Fisheries, Hamburg, for a sample of New Zealand eels kindly sent me in 1912 from a consignment received in Hamburg.

Last, but not least, I thank Mr. Vilh. Ege, M.Sc., and Miss E. Hansen, who, with me, have examined the New Zealand material at the Carlsberg Laboratory in Copenhagen.

## 2. CLASSIFICATION.

The fresh-water eels are probably more abundant in New Zealand than anywhere else in the southern hemisphere. For the Maori, they were of the utmost economical importance, as is evident, for instance, from the highly developed technique in methods and implements for the capture of these fish, possessed by the natives prior to the arrival of Europeans. Thanks to the numerous interesting

<sup>1</sup>Johs. Schmidt: First and Second Report on Eel Investigations (vols. 18 and 23 des *Rapports et Procès-Verbaux du Conseil International pour l'Exploration de la Mer*, Copenhagen 1913 and 1915).

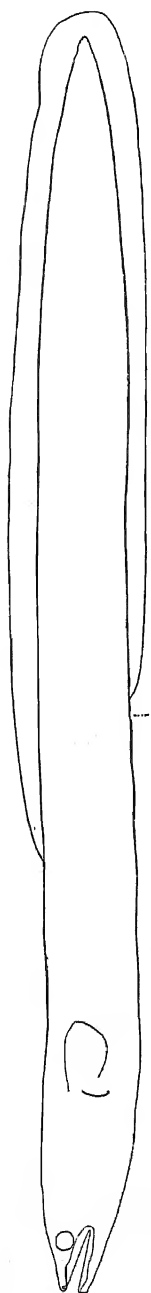


FIG. 1.—*Anguilla aucklandi* Rich., the long-finned eel. Semi-schematic drawing from a specimen 49 cm. in length, by Mr. Vilh. Egg, M.Sc.

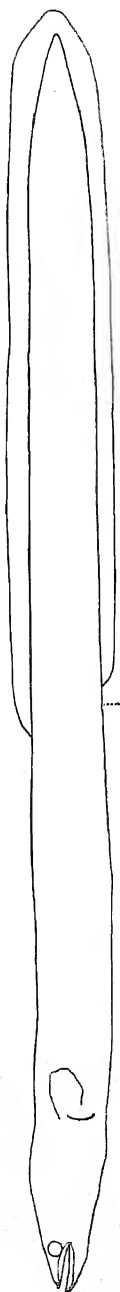


FIG. 2.—*Anguilla australis* Rich., the short-finned eel. Semi-schematic drawing from a specimen 54 cm. in length, by Mr. Vilh. Egg, M.Sc.



This character: the distance between front of the dorsal fin and the vent ( $a-d$ ) is of great value in the classification of the *Anguilla* species. In our investigations, therefore, we determine  $a-d$  in each specimen, and express it as a percentage of the total length ( $\frac{a-d}{t} \times 100$ ).

Fig. 3 shows graphically  $\frac{a-d}{t} \times 100$  in two samples of *A. aucklandi* and *A. australis* respectively. Each dot denotes one eel. It will be noticed that in the 168 specimens of *Anguilla aucklandi*, the value varied between 8.9% and 13.14%, whereas in the sample of the short-finned *Anguilla australis*, the value did not exceed 4.5%. The average values were: for *A. aucklandi* 11.05% and for *A. australis* 2.41%.

Fig. 3 thus shows that  $\frac{a-d}{t} \times 100$  is a "good" character, inasmuch as there was no overlapping in these fairly large samples

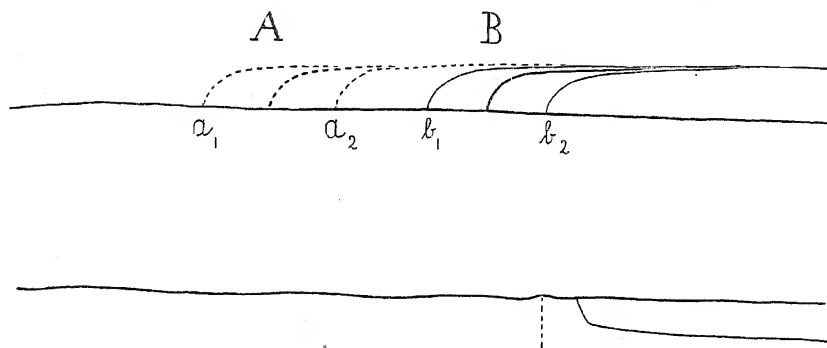


FIG. 4.— $\frac{a-d}{t} \times 100$ : Schematic representation of the variation of this value in the two samples represented graphically in fig. 3.  $A$  and  $B$  = average values;  $a_1$  and  $b_1$  = highest,  $a_2$  and  $b_2$  = lowest values in long-finned eel (*Anguilla aucklandi*) and short-finned eel (*Anguilla australis*) respectively.

of the two species. The same is apparent from the schematic Fig. 4 where the variation of  $\frac{a-d}{t} \times 100$  in the two species is shown in the same figure.<sup>1</sup>

Taking  $a-d$  in the New Zealand eels, there will be very few specimens which cannot be referred with certainty either to the long-finned *A. aucklandi* or to the short-finned *A. australis*. There are, however, a series of other characters which can be employed. Among these should be noted first of all the dentition, or form of the teeth-bands. Fig. 5 shows the teeth-bands of the upper jaw in 6 eels, 3 of either species.

<sup>1</sup> When investigating very large samples, the range of variation will of course be somewhat increased. Up till now, we have found the extreme limits of *A. australis* to be + 5.7% and - 1.4%. (The value is 0 when the dorsal begins immediately above the vent, and negative when the point of commencement lies behind the vent).

These figures, for which I have taken type specimens where possible, illustrate fairly well some of the commonest variations of the dentition in the two New Zealand species. The teeth-bands can, however, be considerably broader, especially in older specimens.

The difference between the two species lies more particularly in the vomerine band, which is longer and narrower in *A. aucklandi* than in *A. australis*. In the latter, the vomerine band is short in proportion to the maxillary bands, and its greatest breadth lies

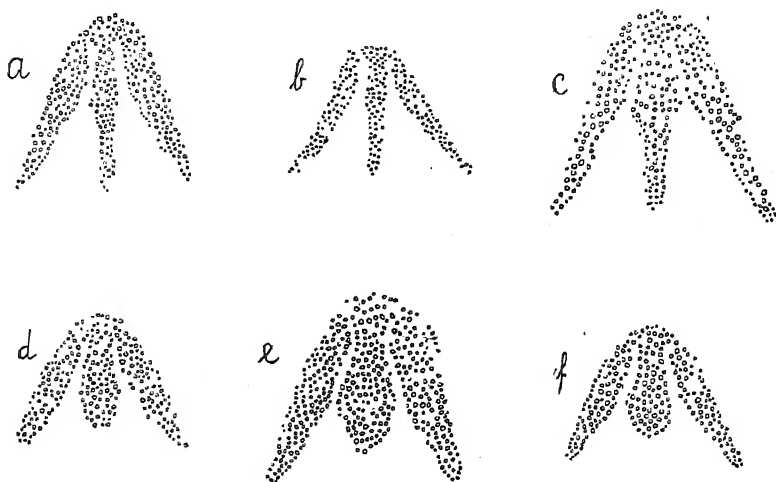


FIG. 5.—Teeth-bands of the upper jaw in 6 eels, 3 of *Anguilla aucklandi*, the long-finned eel (a, b, c,) and 3 of *Anguilla australis*, the short-finned eel (d, e, f).

- a: *Anguilla aucklandi* Rich., Auckland Island, from type in the British Museum.
- b: *Anguilla Dieffenbachii* Gray, New Zealand, from type in the British Museum.
- c: *Anguilla waiteti* Phillips (N.Z. Journal of Science and Technology, 8, No. 1, 1925) Wellington, from type in the Dominion Museum, Wellington.
- d: *Anguilla australis* Rich., Tasmania, from type in the British Museum.
- e: *Anguilla schmidtii* Phillips (N.Z. Journal of Science and Technology, 8, No. 1, 1925) Foxton, from type in the Dominion Museum, Wellington.
- f: *Anguilla australis* Rich., Pipiriki, from specimen collected by the author.

Drawings by Mr. Vilh. Ege, M.Sc.

behind the middle,<sup>2</sup> whereas the greatest breadth in *A. aucklandi* lies farther forward. The vomerine band of *A. australis* is therefore not infrequently shaped like the tongue or clapper of a bell (see figures 5 d, e, f). In *A. aucklandi*, the shape of the teeth bands is extremely variable; the maximal breadth of the vomerine band, however, is hardly ever found to lie behind the middle, as in *A. australis*. The maxillary bands are often much narrower than in *A. australis*.

<sup>2</sup> *Anguilla australis* is distinguished from the other short-finned species of *Anguilla* by its vomerine band, which is generally short and clapper-shaped (see for instance the figure of *A. obscura* Gthr. in my previously quoted work on the Eels of Tahiti).

The number of vertebrae is not a good distinctive character in the case of the two New Zealand species, as it is in so many other

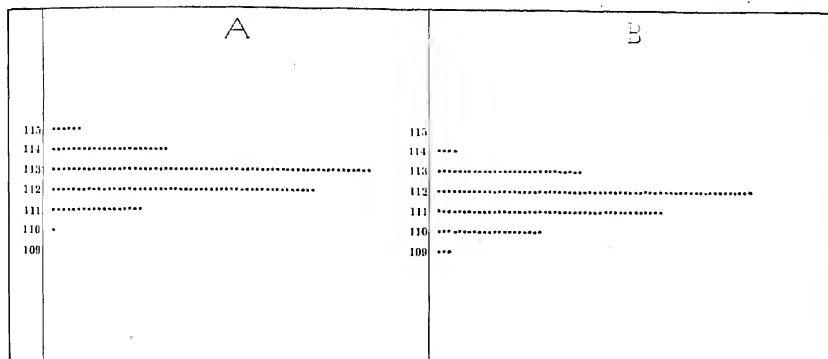


FIG. 6.—Total number of vertebrae in 163 specimens of the long-finned eel (*Anguilla aucklandi*) from Pipiriki, Wanganui River (A) and in 165 specimens of the short-finned eel (*Anguilla australis*) from Poroporo Stream, Waiapu, East Cape (B); averages: 112.66 (*A. aucklandi*) and 111.64 (*A. australis*). — Each dot denotes a specimen.

cases.<sup>1</sup> The total number of vertebrae is shown in the graph Fig. 6. From this it will be seen that the average number is about 1 higher in *A. aucklandi* than in *A. australis* (112.66 as against 111.64).

A rather better character than the total number is the number of praehaemal vertebrae; these are shown graphically in Fig. 7, from which it will be seen that the average is higher in *A. australis* (45.67 as against 44.25).

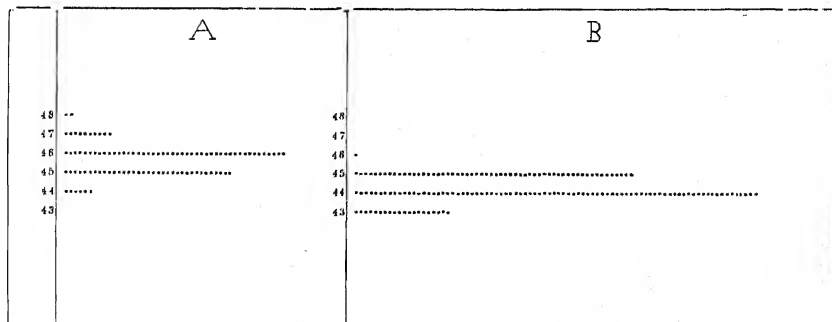


FIG. 7.—Praehaemal number of vertebrae in 99 specimens of the short-finned eel (*Anguilla australis*) from Kaipara Harbour and Thames (A) and in 163 specimens of the long-finned eel (*Anguilla aucklandi*) from Pipiriki (B); averages: 45.67 (*A. australis*) and 44.25 (*A. aucklandi*).—Each dot denotes a specimen.

<sup>1</sup>The slight difference in number of vertebrae is a point which will render it difficult to distinguish between the larvae of the two New Zealand species of Eel, and is thus an obstacle to the study of their life history. It will be impossible, for instance, to distinguish between the larvae by number of myomeres alone, as I was able to do in the Atlantic with the larvae of the European and of the American eel, found in the same places.

Other numerical characters investigated, such as the number of branchiostegal rays and number of pectoral rays, showed slight average differences between the two species.

As will be seen from Figs. 1 and 2, the mouth in *A. aucklandi* is larger than in *A. australis*; the same applies to length of head (distance from gill aperture to point of lower jaw). Furthermore, it will be noticed that the angle of the mouth in *A. aucklandi* extends back a considerable distance beyond the eye, whereas in *A. australis*, this angle lies approximately below the hind margin of the eye. This character is easily discernible in specimens of any reasonable size; it is advisable, by the way, to avoid as far as possible characters which, like the size of the eye and the pectorals, shape of head, etc., depend largely on the age and degree of development of the individual.

It may further be noted that the body in *A. australis* is rather more cylindrical in shape than that of *A. aucklandi*, which is higher, or more laterally compressed.

We have now considered various characters which render it, on the whole, a matter of no great difficulty to distinguish between the two New Zealand species of fresh-water eel. If it is desired to identify one or more specimens, the following should be investigated:

1.  $\frac{a-d}{t} \times 100$ , or the distance between front of dorsal fin and vent expressed in percentage of total length (see Figs. 1-2, 3-4).
2. Shape of the teeth-bands (see Fig. 5).

By means of these two characters, it should be possible in practically every case to determine whether a given specimen belongs to *Anguilla australis* or *Anguilla aucklandi*; finally, one can also take:

3. The position of the eye in relation to the angle of the mouth (see Figs. 1-2).

The eels of New Zealand differ in many ways from those of Europe; notably, however, in attaining a far greater size. The European eel rarely attains a length of 4 feet and a weight of 10-12 lbs. T. W. Downes records New Zealand specimens weighing 38, 46 and 32 lbs., and mentions that on the 2nd May, 1917, fourteen eels were taken in the Moumahaki River, the smallest of which weighed 12 lbs. (*Trans. N.Z. Inst.*, vol. 50, 1918, pp. 300-302.) It is not known whether it is the long-finned or the short-finned species, or both, which attain such enormous weight.<sup>1</sup> In future observations of gigantic eels it would therefore be very desirable to ascertain, in addition to length and weight, the species to which they belong. It will be seen from the foregoing that this can be determined by measuring  $a-d$  and total length; for an expert, examination of the head alone will suffice to show whether it is that of *A. aucklandi* or *A. australis*.

<sup>1</sup> I should here mention that Mr. T. W. Downes, of Wanganui, in a letter dated 2nd April, 1926, sent me a sketch of the dentition of an eel, weighing 23 lbs., which he had caught. It appears from the sketch that the specimen belonged to *Anguilla aucklandi*, the long-finned eel. The maxillary bands were extremely broad, and the vomerine band of peculiar shape, something like that shown in Fig. 5 c, but still more pronounced.

## 3. DISTRIBUTION.

Having had at my disposal some twenty-odd samples, comprising nearly 1,500 fresh-water eels, collected from the most widely different localities in New Zealand, I have endeavoured to ascertain from this material whether *A. aucklandi* and *A. australis* are equally distributed throughout the country, or whether any peculiarities are discernible in the distribution.

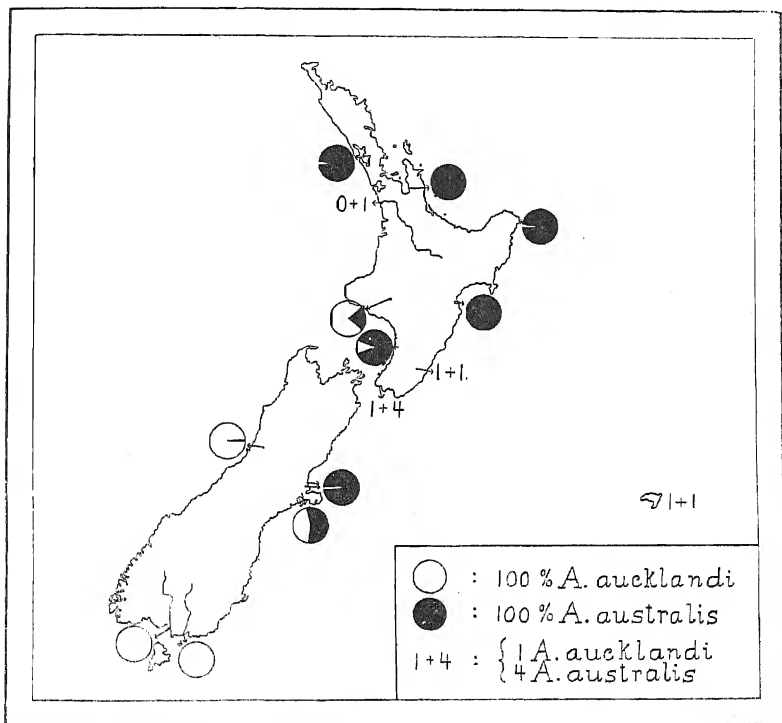


FIG. 8.—Distribution of the New Zealand eels according to the examination of a number of samples consisting of about 1,500 specimens.

The result of the investigations in this connection will be seen from the chart, Fig. 8. Fully blacked circles denote that 100% of the sample consisted of *A. australis*, blank circles that 100% were *A. aucklandi*. Half black, half white denotes that there were 50% of each, and so on.<sup>1</sup>

The chart shows that the distribution of the two species is not uniform. There can be no doubt, for instance, but that *Anguilla aucklandi* belongs mainly to the south and west, *Anguilla australis* chiefly to the north and east.

Further observations are certainly needed, and such will, it is to be hoped, shortly be available; we can already, however, discern a

<sup>1</sup> Only in the case of fairly large samples have the percentages been thus noted; in samples consisting of relatively few specimens, the number belonging to each species is noted. 1 + 4, for instance, indicates that the sample contained in 1 specimen of *A. aucklandi* and 4 of *A. australis*.

characteristic distribution of the two species, which is probably of fundamental importance in biological respects. I will not, however, go further into this question here.

In conclusion, I would merely note the possibility that other species than the two common ones: *A. aucklandi* and *A. australis* may be discovered in New Zealand. It is hardly probable, but should such be found they will most likely be stray specimens of tropical species which have found their way to the northern parts of the North Island. The most likely species is probably *Anguilla reinhardti*, which I found to be common in Lord Howe Island (off New South Wales). It is easily distinguished from the two uniformly coloured New Zealand species however, by its spotted colouring, as well as by many other characters.<sup>1</sup>

Finally, I venture to hope that this brief article may help to arouse further interest in the fresh-water eels of New Zealand. Once the two species are generally recognized as distinct the way will be open for more profitable study of their distribution and life-history.

Carlsberg Laboratory, July 18, 1927.

#### POSTSCRIPT.

On page 366 of my paper on the distribution of the Fresh-water Eels (*Anguilla*) throughout the World, Copenhagen, 1925, (see footnote 2 at the beginning of the present paper) I said about *Anguilla australis*.

"*Anguilla australis* Rich. nec. Boulenger, nec. Weber and Beaufort (New Zealand, Australia and Tasmania). The latter species (i.e., *Anguilla australis*) must probably be subdivided."

After having examined a large number of samples of *Anguilla australis* covering the whole of its area I am now able to say definitely that the species must be subdivided into two forms differing by slight but constant average differences in the number of vertebrae, a—d, etc. I expect to deal with this in a more detailed manner in a paper on the Fresh-water Eels of Australia now under preparation. I may, however, already state here that I propose to divide the species into two forms: *Anguilla australis* Rich. f. *occidentalis* n.f. inhabiting Australia (N.S. Wales and Victoria), Tasmania and Lord Howe Island and *Anguilla australis* Rich. f. *orientalis* n.f. inhabiting New Zealand, Chatham Island, New Caledonia and Fiji, probably also Norfolk Island.

The two species of Fresh-water Eels of New Zealand should thus rightly be called *Anguilla aucklandi* Rich. (long-finned eel) and *Anguilla australis* Rich. forma *orientalis* Johs Schmidt (short-finned eel).

Carlsberg Laboratory, October 22, 1927.

<sup>1</sup> In New Caledonia (about 800 miles from New Zealand) there are, besides *A. reinhardti*, two other spotted species, *Anguilla mauritiana* Bennett and *Anguilla megastoma* Kaup, as well as the short-finned *Anguilla obscura* Gthr. In regard to these, I would refer to my article l.c. on The Fresh-water Eels of Tahiti, from which it will be seen that *Anguilla obscura* Gthr. differs greatly from *A. australis* both in the dentition and in the far smaller number of vertebrae (from 101 to 107, average 103.88).

## Whitebait (*Galaxias attenuatus*): Growth and Value as Trout-food.

By D. HOPE

(Communicated by E. W. BENNETT.)

[Read before the Philosophical Institute of Canterbury, 3rd August, 1927;  
received by Editor, 16th September, 1927; issued separately,  
14th February, 1928.]

PLATES 38, 39.

To the residents of Canterbury of forty years ago, whitebait was a very common article of diet, owing to the immense shoals which ascended our rivers at that period. Among the general public, very little was known of their life-history, and there was a great diversity of opinion as to their identity. To satisfy myself on this point, I carried out a series of experiments at various times at Auckland, Canterbury and Southland, by keeping a quantity of live whitebait in captivity, enclosed in a small pond, as nearly under natural conditions as possible, and noting their growth. The results were the same on every occasion; their growth was extremely rapid, and they reached the adult or Inanga stage in a few weeks, so that I was quite convinced that whitebait was the young of the Inanga.

A controversy having arisen this season (1926) on the subject of trout-food, I again carried out the same experiment. On August 17th, a small quantity of live whitebait was procured and placed in a small but secure pond where they would in all probability find a natural food supply. I preserved one specimen of the whitebait, and another after three weeks, and continued doing this at intervals of three weeks up to fifteen weeks. As may be seen from the photographs the growth was remarkably rapid, especially during the first six weeks (fig. 1).

As these examples of growth were obtained from whitebait kept under natural conditions, and as I had heard the opinion expressed that whitebait remain whitebait always (proof of this statement having allegedly been obtained by keeping them in an aquarium), I carried out another experiment to ascertain the effect of artificial feeding upon their rate of growth. The experiment was on the same lines as the former ones, except that the conditions were more artificial. On October 16th, 1926, I procured a quantity of live whitebait from the Waimakariri, and placed them in a fry-box which had a small stream of water constantly flowing through it. The whitebait were fed regularly on raw liver grated very small, and passed through a fine perforated zinc screen to eliminate the coarser particles. A specimen was preserved on October 16th as whitebait, and further specimens at intervals of one month from that date (fig. 2). The growth was very slow in comparison with the growth of those kept under natural conditions, and it would appear that, as with trout,

food of the requisite quantity and quality is a major determining factor in the rate of growth of whitebait.

The introduction of trout into New Zealand waters was attended with such immense success that the results exceeded the expectations of the most sanguine; the fish rapidly attained to a size and to numbers unheard of in the parent stock, and in a very few years all our rivers were stocked with heavy fish from their sources to the sea. The fact that their introduction has proved such a phenomenal success would suggest that in our New Zealand waters they had found a food-supply which was eminently suited to their needs, and which induced rapid growth. In the case of *Salmo fario*, particularly in the South Island this can be safely attributed to the whitebait, which from their habits and rapid growth formed the staple food-supply of the trout for the greater part of the year.

In those early days they entered our rivers in millions, and ascended to the sources of all the main streams and tributaries, rapidly growing into the adult or Inanga stage, until every pool and backwater was peopled with enormous numbers. The trout followed the shoals upstream, and finding an unlimited supply of food remained there all the summer, thus providing excellent fishing in any part of our streams. In the autumn the Inanga migrated to the sea for the purpose of spawning, and were absent from the rivers during the winter months; this, however, did not affect the trout to any appreciable extent, as from practical experience I have found that they feed very little or not at all during the winter months, and after spawning in the upper waters, drop down to the brackish waters to recuperate. In the early spring they again commence to feed, and they then feed ravenously. It was just at this period that the whitebait made their appearance, leading them upstream, where they rapidly regained condition.

At the present time, however, conditions have altered considerably, through the increase in population and the consequent increase in the demand for whitebait as a table delicacy. The greater portion are now taken at the mouths of our rivers as they enter, and in comparison very few are allowed to ascend. In consequence, very few Inanga are now found upstream, and few descend to the sea in autumn to perpetuate their species. This has had a very marked effect upon our trout fishing. With the decline of the Inanga there has been a corresponding decline of the trout; the latter have deserted the upstream waters, and are now found only near the mouths of our large rivers, where their principal food is the Silvery (*Retropinna Richardsonii*). These latter fish enter the rivers during the spring and early summer for the purpose of spawning, but do not ascend much above the influence of the tides. After spawning, they again return to the sea, and the trout follow them; in this respect the influence of the Silvery upon the trout is the opposite to that of the whitebait. It has caused our Brown Trout to alter their habits and become migratory. They now live the major portion of their lives in the sea, and enter the rivers only in company with the Silveries, or for the purpose of spawning in late autumn.

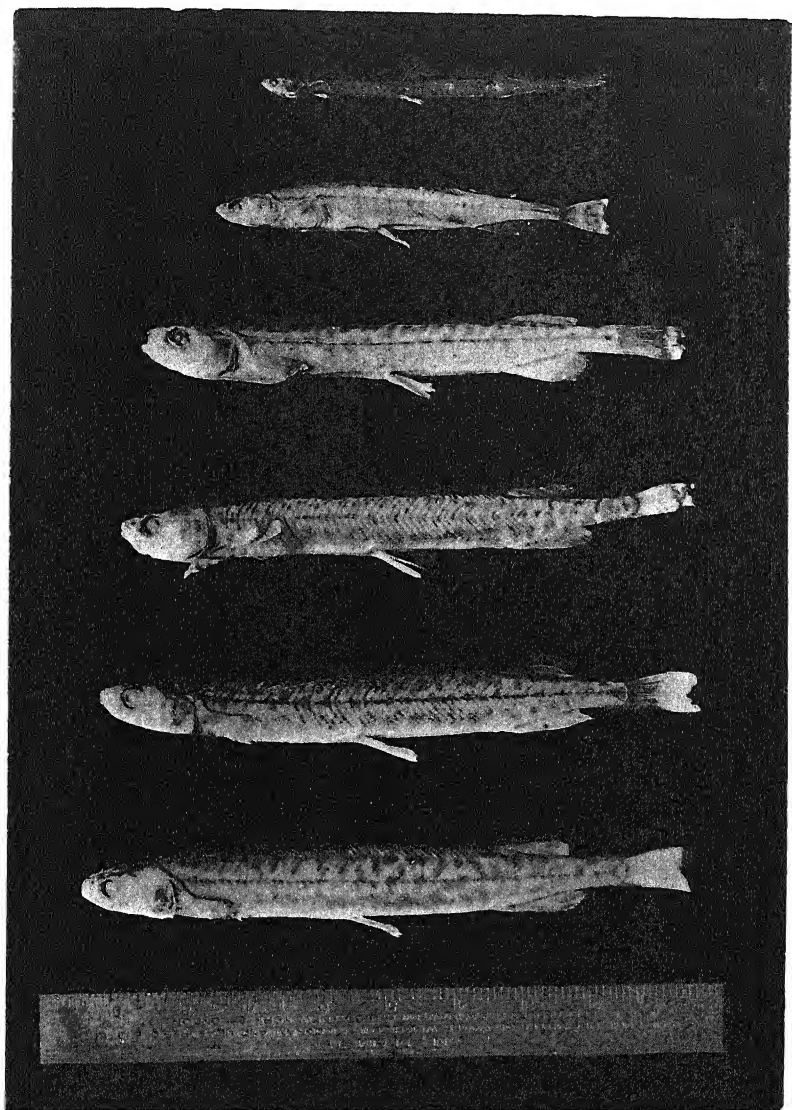


FIG. 1.—*Galaxias attenuatus*. Specimen as whitebait on 17th August, 1926, and at intervals of three weeks up to fifteen weeks. Under natural conditions as to food, etc. Slightly reduced.

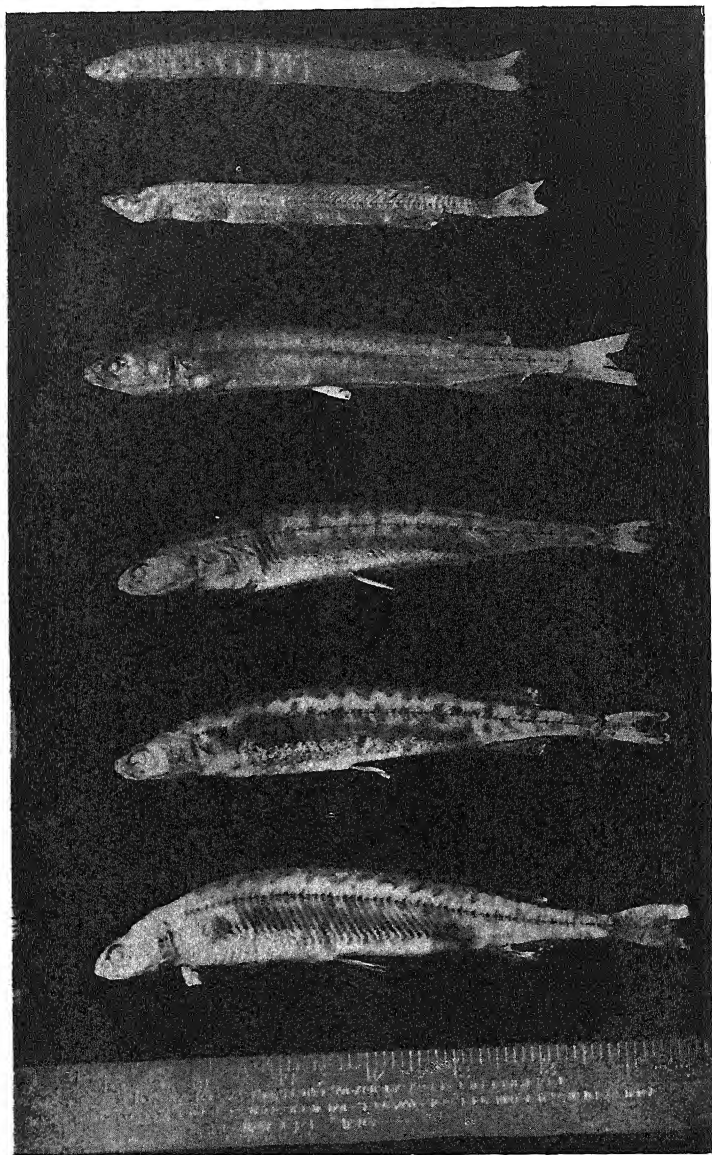


FIG. 2.—*Galaxias attenuatus*. Specimen as whitebait on 16th October, 1926, and at intervals of one month up to five months. Under artificial conditions as to food, etc.

The whitebait fishery is a most important industry, and from an economic point of view a very valuable national asset; but under the present system of fishing the whitebait is in extreme danger of extermination. At the present time there is not even a defined season for taking whitebait; they may be taken from the time they make their first appearance until they cease running. In the case of our native and imported game, a season is provided, and if it is deemed necessary a closed season is enforced. On the west coast of the South Island a whitebait cannery is established, and there is in addition a cannery boat, which has been used to fish the practically virgin streams of south Westland, the last stronghold of the whitebait. Before the advent of the Midland Railway to Westland, the cost of transport was prohibitive; but at the present time large quantities are forwarded each season to supply the demand in Christchurch. Accordingly, there has also been a considerable increase in the number of men engaged in the whitebait fishery.

As each individual whitebait is potentially an *Inanga* capable of reproducing its species, this indiscriminate fishing without restriction must eventually lead to disaster, unless steps are taken to conserve them before it is too late. The Government, through the Tourist Department, spends large sums each year advertising New Zealand to attract visitors to our shores for our famous fishing and scenic attractions; and at the same time it entirely neglects the main cause of the fame of our fishing.

**The Rediscovery of *Tonicia cuneata* Suter and *Acanthochites thileniusi* Thiele (Order Polyplacophora) together with the Description of a new Genus and Short Review of the New Zealand Acanthochitonidae.**

By EDWIN ASHBY, F.L.S.

(Communicated by ALBERT E. BROOKES.)

[Read before Auckland Institute 20th August, 1926; received by Editor, 2nd September, 1926; issued separately, 14th February, 1928.]

PLATE 40.

FOREWORD.

MR. ALBERT E. BROOKES is to be congratulated on his rediscovery of the shell described by Suter in 1908, under the name *Tonicia cuneata*, hitherto only known from the two examples collected by the late Mr. J. C. Anderson in the Bay of Islands. Now, after a lapse of nearly twenty years, Mr. Brookes has rediscovered it 200 miles further south. To him we are also indebted for another important discovery from the same locality, Tauranga Harbour; that of *Acanthochiton thileniusi* Thiele, described by Dr. Thiele in 1910 from the same harbour; the type unfortunately remains in a European Museum. I make my grateful acknowledgments to Mr. Brookes for the gift of the specimens that form the subject-matter of this paper.

*Note.*—Since the completion of this paper and its placing in the hands of Mr. Brookes, the writer has been informed that the date of publication of his earlier paper "The Acanthoid Chitons of New Zealand," quite unintentionally on his part, antedates the publication of Miss Mestayer's paper entitled "New Zealand Mollusca, No. 3"; a paper that was read on 22nd October, 1924. This unfortunate occurrence makes the writer the author of the names *Notoplax oliveri*, and *N. foveauxensis*, and his specimens and descriptions thereof, the types. These latter are being presented to the Dominion Museum, Wellington, and the rest of the writer's types to the Auckland Museum.

**Pseudotonicia n. gen.**

Having only 4 slits in the anterior valve, teeth sharp, median valves slits 1/1, tail-valve multislit as in *Notoplax*; the whole of the tegmentum bears numerous minute sense-organs that may have the same function as the "eyes" in the genus *Tonicia* or be a special development of the "megapores"; gill-rows short, girdle clothed with minute, spaced spicules appearing nude, except under magnification; sutural hair-tufts obsolete or subobsolete.

## Family ACANTHOCHITONIDAE Hedley.

## Subfamily PSEUDOTONICINAE Ashby.

Genus *Pseudotonicia* Ashby.

## PSEUDOTONICIA CUNEATA Suter.

*Tonicia cuneata* Suter, *Trans. N.Z. Inst.* vol. 40, pp. 360-361, pl. 28, figs. 1-2, 1908.

*Craspedochiton cuneata* Iredale, *Trans. N.Z. Inst.* vol. 47, p. 485, 1914.

Ashby in "The Acanthoid Chitons of New Zealand," *Proc. Mal. Soc. Lond.* vol. 17, pt. 1, pp. 5-35, pls. 1-4, April, 1926, states: "The character of the anterior insertion plate (4 slits) and the fact that the valves are bestrewn with immense numbers of minute eyes, precludes the possibility of its inclusion under the subfamily Acanthochitoninae."

## CLASSIFICATION.

Mr. Brookes has supplied me with four examples of this shell, one a disarticulated paratype (one of the original two specimens) from the collection of the late Mr. J. C. Anderson, now in the collection of Brookes. (2) A very fine specimen in spirit. (3 and 4) Dry, more or less damaged specimens.

For the purpose of comparison with the genus *Tonicia*, I disarticulated an example from my own collection of *T. elegans*, the type species of that genus. All valves have strongly pectinated insertion-teeth; the lateral areas and the end-valves bear radiating rows or bands of eye-dots, and the gills extend the whole length of the foot.

I also disarticulated an example of *Lucilina suezensis*, the type of that subgenus, and found that the insertion-plates were similar to those of the genus *Tonicia*; the only distinction seems to be the position of the mucro in the tail-valve, certainly a non-generic character, and at most can only warrant subgeneric distinction. In the genus *Onithochiton*, the insertion-plate of the anterior valve is pectinated like *Tonicia*, but the insertion-plate of the tail-valve is reduced to a low, smooth and narrow callus. In Suter's *Tonicia cuneata*, the insertion-plate of the anterior valve is quite dissimilar from that of the three genera above referred to, the teeth being unpectinated and sharp, also the gills do not extend the full length of the body. The minute "eyes" mentioned by Suter are present in all valves, but the larger of these apertures has a diameter of only about 12.5 mm., whereas in *Tonicia* they have a diameter of about 50 mm., and in *Onithochiton scholvi* of about 25 mm. (these measurements are my own); thus it will be noted that whatever may be the function of these "eye-dots" in *cuneata*, they are much smaller than the typical "eyes" of other genera. We are therefore able to determine that the insertion-plate of *cuneata* is certainly Acanthoid in character, though the four to five variable slits, instead of the typical 5 slits of the Acanthochitoninae, and the existence of numerous "eye-dots," separate it from that subfamily. We certainly are justified in its inclusion under the

family Acanthochitonidae. This course is further supported by the discovery by the writer of subobsolete sutural hair-tufts in the specimens in spirit referred to below. The insertion-plate of the anterior valve of the genus *Craspedochiton* is not Acanthoid in character, being deeply festooned as Pilsbry terms it; Iredale must have been unaware of the true characteristics of that genus when he proposed the inclusion of *cuneata* therein.

## DESCRIPTION.

*General appearance.*—Valves reduced, girdle very broad, encroaching on the valves at sutures, shell smooth surface, anterior valve ray-ribbed, lateral area defined by a diagonal fold, pleural area more or less deeply longitudinally grooved, deep wedge-shaped notches margining these grooves, dorsal area well defined, broad, smooth, and beaked, mucro post-median, colour, valves pink, girdle buff.

*Anterior valve.*—This spirit specimen shows only three ray-ribs, the two disarticulated specimens show four, corresponding to the four slits, as in Suter's type; (Mr. Brookes has now in his collection three specimens showing five distinct rays, with corresponding slits); the surface of shell between ribs is smooth except for slight growth-lines and a few deep cuneiform excavations in upper half of shell.

*Median valve.*—Dorsal area beaked, smooth, broadly wedge-shaped, shallowly notched at margin (pinnatifid); pleural area with 4 to 6 deep longitudinal grooves margined with deep triangular notches or excavations; lateral area with a distinct fold separating it and pleural area; decoration irregular, and consists of more or less wedge-shaped excavations.

*Posterior valve.*—Dorsal area as in other valves, mucro post-median several longitudinal grooves similar to pleural area in other valves, posterior portion behind mucro shallow (flattish), slope almost straight, ornamentation consisting of irregular excavations.

*Girdle.*—Greatly expanded, and occupies fully two-thirds of total width of animal, encroaches greatly at sutures; upper side of girdle "spongy" to the naked eye or under a low-power pocket lense and apparently without spicules, hair-tufts, or pores (as stated by Suter); but under 65 mag. girdle is seen to be clothed with spaced, adpressed, minute spicules, varying in length from  $4/200$  to  $6/200$  mm. or 20 to 30 mm. Underside of girdle clothed with adpressed glassy spicules or modified hair-like scales. With a pocket lens the writer was unable to find any evidence of sutural hair-tufts, but under 65 mag. the existence of three sub-obsolete hair-tufts was noted on the two dry specimens, but under a similar magnification the specimen in spirit was found to possess some evidence of sub-obsolete hair-tufts at all sutures. No sutural pores detected, but slender curved spicules noted, three times the length of the other girdle-spicules, the longest measured being  $14/200$  mm. or 70 mm.

*Inside.*—White, anterior valve 4 slits, equidistant, broad and deep, groove continued to tegmentum, teeth sharp and straight-edged,

articulamentum thick and broad, here and there narrowly ridged, slits corresponding with ray-ribs; median valves slits 1/1, posterior valve irregularly slit as in genus *Notoplax*.

*Measurements*.—Of spirit specimen, total length 42 mm., width 23 mm. of which the girdle occupies two-thirds, total length of body, *i.e.*, foot and head, 33 mm. of which head occupies 5 mm., width of foot a bare 10 mm., width of head 8 mm., gills post-median, 20 gill-slits counted which commence 4 mm. in front of anal extremity and extend forward 17 mm.

*Remarks*.—Suter's excellent description compared with the foregoing will give some idea of the margin of variation but he was incorrect in stating that the girdle was almost naked with very few silvery hairs near the margin. I have not seen any marginal fringe and the apparent absence of spicules under a low power is misleading, for minute spicules are distributed all over. Suter was also quite unaware of the sub-obsolete hair-tufts; again, he was incorrect in stating that the teeth in the first seven valves are finely pectinated, because in the usual acceptance of the term as applied to the genus *Tonicia* they are not pectinated at all; a glance at the figure of *Tonicia* will at once show the difference; Suter's statement "with gills extending nearly the whole length of the foot" is hardly correct, as a reference to the within measurements will show that the gills are but little more than half the length of the foot.

I consider *Pseudotonicia cuneata* to be a specialized form belonging to the family Acanthochitonidae; and whereas in the subfamily Cryptoplacinae the slits of the anterior valve are reduced to 3, in this species they are reduced to 4. As this feature is persistent, it will seem advisable to erect for its reception a subfamily Pseudotonicinae, immediately following the subfamily Acanthochitoninae.

*Addenda*.—Since the completion of the paper Mr. Brookes informs me that he has obtained three additional examples of *Pseudotonicia cuneata*, in each of which the anterior valve possesses 5 rays with corresponding slits in the insertion-plate. It is quite evident that the reduction of slits in this valve to four is not constant, and I have therefore asked Mr. Brookes to correct letterpress making the description read "4 or 5 slits" and I take this opportunity of expressing grave doubts as to whether the existence of the "minute eye-dots" is, taken by itself, sufficient grounds to warrant the retention of the proposed new subfamily Pseudotonicinae; if not, then this genus will have to be relegated to a position under the subfamily Acanthochitoninae.

*Habitat*.—Brookes collected all his specimens in Tauranga Harbour, opposite the town, in three fathoms. The two damaged specimens referred to were obtained from the mooring chain, and the others from the spoil deposited by the dredge engaged in deepening the approach to the new wharf. Bottom of hard pumiceous formation. The original specimen described by Suter came from the Bay of Islands.

**Acanthochiton thileniusi.**

*Acanthochites thileniusi* Thiele, *Rev. des Sys. der Chitonen*, pp. 50-51, pl. 6, figs. 55-58, 1909.

*Acanthochites tristis* Iredale, *Proc. Mal. Soc. Lon.* vol. 9, pt. 3, p. 155, 1910, not of Rochebrune.

*Acanthochites* (*Acanthochiton*) *bisulcatus* Wissel, *Zool. Jahrb. Sys.*, vol. 20, p. 614, pl. 21, figs. 28-29 (anatomy), only applies to examples from Tauranga; not of Pilsbry.

*Acanthochites zealandicus thileniusi* Ashby, "The Acanthoid Chitons of New Zealand," *Proc. Mal. Soc. Lon.*, vol. 17, pt. 1, pp. 13-14, pl. 4, figs. 5-7.

*Introduction.*—In the writer's paper "The Acanthoid Chitons of New Zealand" (*l.c.*), he gave an English translation of Thiele's description, and commented on points of difference between an example in his own collection that had originally been sent to him by the late Henry Suter, the data as to locality having been lost; it will therefore be unnecessary to reproduce that translation, only quoting the following comments.

"Thiele makes reference to longitudinal grooving in the dorsal areas, and this at first led me to conclude that his shell was conspecific with the deeply-grooved shell hereinafter described under the name *brookesi*; a reference to Thiele's figure of the tail-valve entirely precludes such a possibility. Thiele also described *A. zealandicus* as having longitudinal grooving in the dorsal areas; I therefore conclude that in both cases his remark refers to sub-cutaneous lining, which so simulates grooving that its true character can only be determined by the use of a binocular microscope and lateral lighting."

The rediscovery of *A. thileniusi* at the type locality by Brookes enables the question of the longitudinal grooving in the dorsal areas to be finally settled; he has given me two of his Tauranga specimens, and these show distinct longitudinal grooving in the dorsal areas, but the riblets are about half the width of the corresponding riblets in *Brookesi* Ashby, the grooving much shallower, and their structure when seen under a microscope quite distinct.

*Comparison with Allied Forms.*—Although I still consider *thileniusi* to belong to what I call the *zealandicus* section of the genus *Acanthochiton*, the very definite grooving and peculiar sculpture of the riblets of the dorsal areas justifies the erection of this species to full specific rank.

In *thileniusi* the dorsal area is a little narrower than in either *zealandicus* or *doubtlessensis*, but very similar to this area in *brookesi*; in both *zealandicus* and *doubtlessensis* longitudinal grooving in this area is absent, but present in *thileniusi* and *brookesi*; in the former the riblets are sinuate and rugose, the grooves between being very shallow, the riblets between the grooves varying in width from about 50 to 62 mm.; in *brookesi* these riblets are not wavy and rugose but straight and comparatively smooth, and the grooves between much deeper; the width of these riblets varies from about 62 to 100 mm.; the coarser riblets are formed by the confluence of two narrower ones and often show a shallow mid-groove.

The tail-valves of *zealandicus*, *thileniusi*, and *doubtlessensis*, are all small and very similar in shape, although the tegmentum of the latter is proportionally smaller; the tail-valve of *brookesi* is large, being three times the size of the others, and the insertion-plate suggests a transition towards the genus *Notoplax*, thus placing that species in a different section of the genus *Acanthochiton*.

The flat, somewhat circular granules in the pleural areas of the median valves, measure in *thileniusi* about 100 by 137 mmm.; in *zealandicus* 90 by 125 mmm.; but in *doubtlessensis* they measure 137 by 200 mmm.

*Habitat*.—Dredged by Brookes in one and a half fathoms low spring-tide on shells of live *Mytilus*, close to entrance Tauranga Harbour.

#### *Acanthochiton doubtlessensis*.

*Acanthochiton zealandicus doubtlessensis* Ashby, *Proc. Mal. Soc. Lon.* (l.c.).

The proposed elevation of Thiele's shell to full specific rank suggests the desirability of similarly elevating *doubtlessensis*. Quoting from my paper (*op. cit.*): "This form differs from *zealandicus* s.s. in the whole shell being much less raised; in the form of the median valves which are very flat and longitudinally short; in the sculpture, the granules being more elongate, definitely larger and more widely spaced; in the tail-valve having the posterior slope, behind mucre, less vertical."

I have above supplied the actual measurements of the granules in comparison with allied forms, and have pointed out that the tegmentum of the tail-valve of this species is proportionately smaller than that of its congeners. I hesitated in my earlier paper to grant full specific rank because of the very limited number of localities from which specimens of *zealandicus* were available, and feared the possibility that there might exist a gradual transition from the form from French Pass, the type locality (my specimens from Lyall Bay I consider typical), to the coarsely sculptured form from Doubtless Bay. Reviewing this, and with the concurrence of Mr. Brookes, I now suggest that this form be recognized as a good species and not a subspecies of *zealandicus*, although with *thileniusi* it must be recognized as belonging to that section which we have called *zealandicus* section of the genus *Acanthochiton*.

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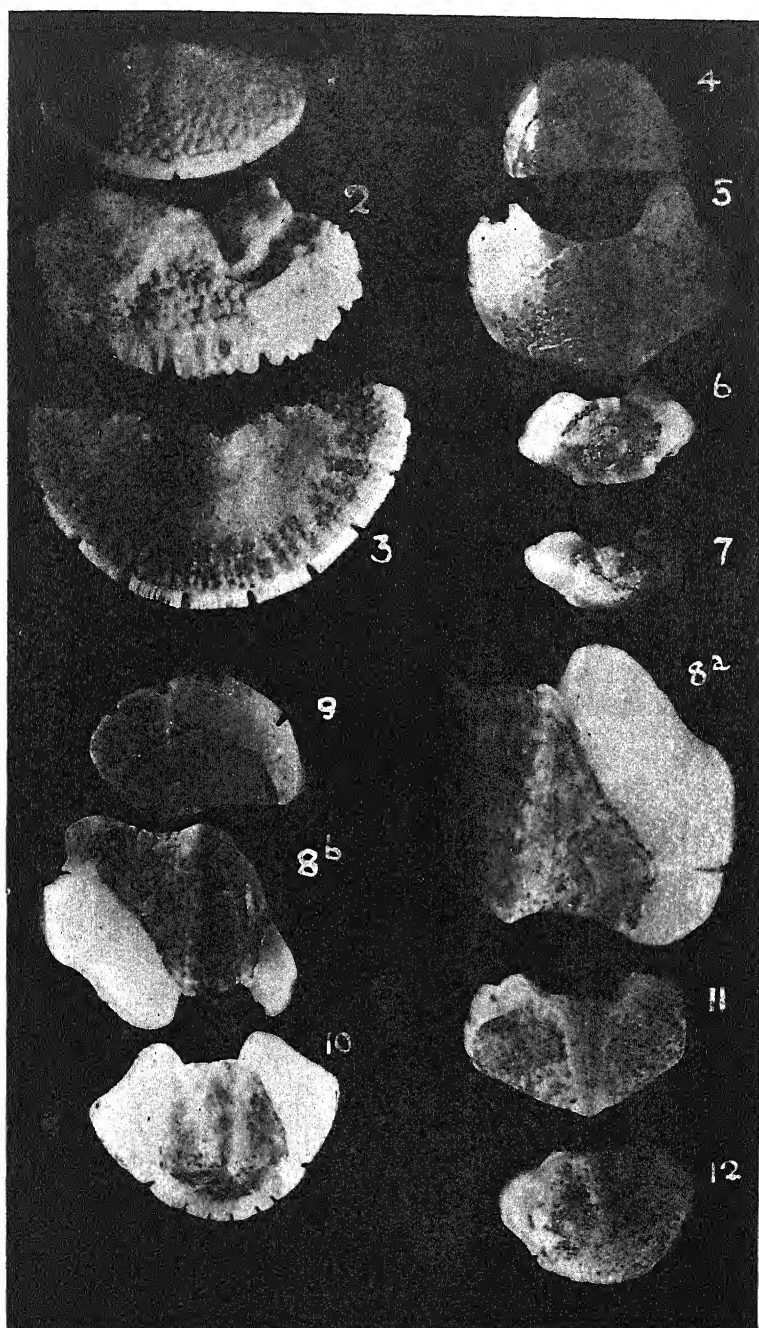
#### The Synonymy of New Zealand *Acanthochitonidae*.

With a brief summary of the author's paper "The Acanthoid Chitons of New Zealand" (l.c.).

In his paper on "The Acanthoid Chitons of New Zealand" (l.c.), the writer points out some of the relationships between the Australian and the Neo Zealandic faunas, referring briefly to the part the ocean-currents have played in this faunal distribution. Under the heading

## EXPLANATION OF PLATE.

- FIG. 1.—*Notoplax* (*Amblyplax*) *foveauxensis* Ashby. Foveaux Strait; anterior valve, showing narrow insertion and sharp teeth. Ashby Coll. X6.
- FIG. 2.—*Craspedochiton joubertensis* Ashby. Dgd. off Cape Joubert, Northern Australia; holotype anterior valve, showing broad, festooned and fluted insertion plate, for comparison with Fig. 1, which has wrongfully been placed in the same genus. Ashby Coll. X6.
- FIG. 3.—*Tonicia elegans* Fremb. Chili. Anterior valve for comparison with Fig. 9, which has been wrongfully assigned to the same genus. Showing narrow insertion plate, highly pectinated and laminated, and scattered eye pits, visible in tegmentum. Ashby Coll. X6.
- FIG. 4.—*Acanthochiton thileniusi* Thiele. Tauranga Harb. Plesiotype, anterior valve. Ashby Coll. X6.
- FIG. 5.—*Acanthochiton thileniusi* Thiele. Tauranga Harb. Plesiotype, median valve. Ashby Coll. X6.
- FIG. 6.—*Acanthochiton thileniusi* Thiele. Tauranga Harb. Plesiotype, tail valve. Ashby Coll. X6.
- FIG. 7.—*Acanthochiton doubtlessensis* Ashby. Doubtless Bay. Holotype, tail valve, showing small tegmentum and lateral extension of insertion plate and sutural laminae. Ashby Coll. X7.
- FIG. 8a—*Pseudotonicia cuneata* Suter. Tauranga Harb. Plesiotype, half median valve, showing longitudinal and cuneiform grooving. Ashby Coll. X7.
- FIG. 8b—*Pseudotonicia cuneata*. Same valve as 8a, X about 5.
- FIG. 9.—*Pseudotonicia cuneata* Suter. Tauranga Harb. Plesiotype, anterior valve, showing broad insertion plate, sharp teeth, 4 slits. Ashby Coll. X about 5.
- FIG. 10.—*Pseudotonicia cuneata* Suter. Tauranga Harb. Plesiotype, tail valve, 7 slits. Ashby Coll. X about 5.
- FIG. 11.—*Acanthochiton brookesi* Ashby. (?) Auckland. Holotype, median valve, showing longitudinal grooving in dorsal area. Ashby Coll. X7.
- FIG. 12.—*Acanthochiton brookesi* Ashby. (?) Auckland Harb. Holotype, tail valve, showing rounded shape, large size of valve, very large tegmentum, posterior insertion plate narrow and notched. Ashby Coll. X7.





“*Classification Discussed*” the shell referred to by Iredale and others under the name *Craspodochiton rubiginosus* is shown to have no relationship with that genus, which up to the present is not represented in the Dominion by any known species. A photograph of the insertion-plate of the anterior valve of *Craspodochiton joubertensis* Ashby, is figured; it suggests no affinity with the family Acanthochitonidae; instances are given demonstrating the unwisdom of treating as of generic value purely superficial characters.

The whole of the New Zealand representatives of the subfamily Acanthochitoninae are placed under the following genera and subgenera.

Genus *Acanthochiton* Gray.

Genus *Notoplax* H. Adams.

Subgenus *Loboplax* Pilsbry.

Subgenus *Amblyplax* Ashby.

Provisional genus *Lophoplax* Ashby.

Genus *Cryptoconchus* Burrow.

The fact that the law of priority, as applied to generic names, does not apply to Ordinal or Family names is pointed out, and reference is made to Article 5 (Int. Rules) which reads: “The name of a family or subfamily is to be changed when its type genus is changed.” Obviously the genus *Acanthochites* Risso. is the type genus of the group referred to in the said paper, and the author considers that Iredale has advanced no valid reason for the establishment of his family name Cryptoconchidae. Under Article 5 quoted above and Article 4, on changing the generic name of Risso. *Acanthochites* 1826, to that of *Acanthochiton* Gray em. 1821, which antedates it, we should change the family name to Acanthochitonidae Hedley, with the subfamily name Acanthochitoninae Ashby. On the same grounds the writer does not adopt Iredale and Hull’s proposal to change the familiar ordinal name of Polyplacophora and the vernacular name of Chiton to Loricata and Loricates respectively. To adopt such a suggestion can serve no useful purpose, and is in the writer’s opinion an attempt to do a distinct disservice to workers and students the world over.

#### CLASSIFICATION ADOPTED.

Class AMPHINEURA.

Order POLYPLACOPHORA.

Family ACANTHOCHITONIDAE Hedley 1916.

Subfamily ACANTHOCHITONINAE Ashby 1925.

Having 5 slits in insertion-plate of anterior valve, sutural hair-tufts in girdle.

Genus *Acanthochiton* Gray em. 1821.

Having 5 slits in insertion-plate of anterior valve, 2 slits in tail-valve, teeth sharp, sutural hair-tufts in girdle.

**Acanthochiton zelandicus.**

*Chiton zelandicus* Quoy and Gaimard, 1835, *Voy. Astrol.*, vol. 3, p. 400, pl. 73, figs. 5-8.

*Acanthochites zelandicus* Pilsbry, *Man. Conch.* vol. 15, p. 16, pl. 14, figs. 9-10; *Proc. Mal. Soc. Lon.*, 2, p. 192.

*Acanthochites hookeri* in Dieff. *N.Zd.* 2, 262.

*Acanthochites spiculosus* var. *astringa* Wissel, *Zool. Jahrb. Systs.* vol. 20, p. 612, pl. 21, fig. 25, pl. 23, figs. 28-29 (anatomy), not of Reeve.

*Acanthochites* (*Acanthochiton*) *bisulcatus* Wissel, *op. cit.* p. 614, pl. 21, figs. 28-29 (anatomy). Note French Pass examples only, not of Pilsbry.

*Acanthochites zelandicus* Thiele, *Rev. des Syst. der Chitonen*, pt. 1, p. 50, pl. 6, figs. 51-52.

*Acanthochiton zelandicus* Iredale, *Trans. N.Z. Inst.* vol. 47, p. 425, 1915.

Type from French Pass, in Mus. d'Hist. Nat. Paris.

**Acanthochiton doubtlessensis.**

*Acanthochiton zelandicus doubtlessensis* Ashby. "The Acanthoid Chitons of N.Z." (*l.c.*). Type from Doubtless Bay.

**Acanthochiton thileniusi.**

*Acanthochites thileniusi* Thiele (*l.c.*) pp. 50-51, pl. 6, figs. 55-58, 1900.

*Acanthochites tristis* Iredale, *Proc. Mal. Soc. Lon.* vol. 9, p. 155, not of Rochebrune.

*Acanthochites* (*Acanthochiton*) *bisulcatus* Wissel (*l.c.*), not of Pilsbry. (Only applies to examples from Tauranga.)

*Acanthochiton zelandicus thileniusi* Ashby, "The Acanthoid Chitons of N.Z." (*l.c.*). Type from Tauranga Harbour in Mus. d'Hist. Nat. Paris.

**Acanthochiton brookesi.**

*Acanthochiton brookesi*, Ashby, "The Acanthoid Chitons of N.Z." (*l.c.*) Type believed to be from Auckland Harbour; presented to Auckland Museum.

**Genus NOTOPLAX.**

H. Adams *P.Z.S.* 1861, p. 385. Type *N. speciosus* from Tasmania. Having multifissate tail-valve, insertion-plates and teeth sharp, with or without ray-ribs in the anterior valve.

**Subgenus LOBOPLAX Pilsbry 1893.**

Pilsbry *Naut.* 1893, vol. 3, p. 32. Type *Chiton violaceus*, Quoy and Gaimard.

Having multifissate tail-valve, broad insertion-plate at tail, teeth sharp, great extension of girdle which is naked.

*Note.*—Ashby points out in *Trans. Roy. Soc. S. Austr.* vol. 45, 1920, p. 289, that Dall's genus *Macandrellus* falls, as it was founded on *Acanthochiton costatus* Ad. and Ang. as type, and that species is a true *Notoplax*.

**Notoplax (Loboplax) violaceus.**

*Chiton violaceus* Quoy and Gaimard, *Voy. Astrol.* 3, p. 403, 1835.

*Chiton violaceus* Gould., *U.S. Expl. Exped. Moll.*, p. 331, fig. 420.

Not *Chiton violaceus* Reeve, *Conch. Icon.*, fig. 41.

*Chiton porphyreticus* Reeve, *Conch. Icon.*, vol. 10, fig. 56, 1847.

*Phacellopleura porphyretica*, Cp.M.S.

*Loboplax violaceus* Pilsbry, *Man. Conch.* vol. 40, p. 39, figs. 67-73;

*Proc. Mal. Soc. Lon.*, 2, p. 193.

*Acanthochites violaceus* Wissel (*l.c.*) 20, 616, pl. 21, fig. 30; pl. 23, figs. 31-32 (anatomy).

*Loboplax violaceus* Thiele (*l.c.*), pp. 37-39.

*Macandrellus violaceus* Iredale, *Trans. N.Z. Inst.* vol. 47, 1914, p. 425.

*Acanthochiton violaceus* Ashby, *Trans. Roy. Soc. S. Austr.* vol. 46, 1922, p. 578.

Ashby in "Acan. Chitons of N.Z." gives photographs of one of Quoy and Gaimard's co-types. In Ashby collection.

**Notoplax (Loboplax) violaceus var. papilio.**

*Chiton violaceus* var. *papilio* Quoy and Gaimard, *Voy. Astrol.*, p. 520.

*Acanthochiton violaceus* var. *Papilio* Ashby (*l.c.*), p. 578.

*Loboplax violaceus* var. *papilio* Ashby, in "Acanthoid Chitons of N.Z." (*l.c.*)

Type in Mus. d'Hist. Nat. Paris.

**Subgenus AMBLYPLAX Ashby, 1926.**

Ashby, "Acanthoid Chitons of N.Z." *Proc. Mal. Soc. Lon.*, vol. 17, pt. 1, p. 18, type *Notoplax (Amblyplax) oliveri* Ashby = *Macandrellus oliveri* Mestayer.

Having multifissate tail-valve, posterior insertion-plate narrow, thickened, blunt-edged and fluted; girdle clothed with spicules or irregular, minute scales or both, girdle often asymmetrical.

Ashby, while using the names *Loboplax* and *Amblyplax* subgenerically, points out that they might with equal justice be considered sections only of the genus *Notoplax*, though the arrangement adopted seems the more convenient.

**Notoplax (Amblyplax) oliveri.**

*Notoplax (Amblyplax) oliveri* Ashby. *Proc. Mal. Soc. Lon.* vol. 17, pt. 1, April 1926, pp. 18-20, pl. 1, figs. 4 a, b, c.

*Macandrellus oliveri* Mestayer, *Trans. N.Z. Inst.*, vol. 56, May 1926.

Ashby supplies photographs and gives a full description of a specimen dredged in 20fms. by Albert E. Brookes, on *Atrina* shell, between Kawau and Tiritiri Islands, Hauraki Gulf.

**Notoplax (Amblyplax) foveauxensis.**

- Notoplax (Amblyplax) foveauxensis* Ashby. *Proc. Mal. Soc. Lon.* vol. 17, pt. 1, April 1926, pp. 20-22, pl. 1, figs. 5 a, b, c.  
*Acanthochiton foveauxensis* Mestayer. *Trans. N.Z. Inst.* vol. 56, pp. 585-6, pl. 100, figs. 9-12.  
*Acanthochiton foveauxensis* var. *kirki* Mestayer. (*l.c.*), pp. 586-587, pl. 101, figs. 1-4.  
*Loboplax rubiginosus* Thiele, *Rev. des Syst. der Chitonen*, p. 38, pl. 5, figs. 16-17, 1909, not of Hutton.  
*Acanthochites rubiginosus* Suter, *J. Mal.* 12, 68, pl. 9, figs. 12-17, not of Hutton.  
*Plaxiphora terminalis* Wissel (*l.c.*), p. 609, pl. 21, fig. 22; pl. 23, figs. 23-24 (anatomy), not of Smith.  
*Acanthochites rubiginosus* Iredale, *Proc. Mal. Soc. Lon.* vol. 9, pt. 3, p. 155, 1910. Stewart Island shells, not of Hutton.  
*Craspodoichiton rubiginosus* Iredale, (*l.c.*), vol. 11, pt. 2, p. 130, 1914, not of Hutton.  
 Ashby gives photographs and full description.  
 Type Foveaux Strait. Presented to Dominion Museum.

**Notoplax (Amblyplax) rubiginosus.**

- Tonicia rubiginosa* Hutton, *Trans. N.Z. Inst.*, vol. 4, 1872, p. 180.  
*Acanthochites costatus* Suter, *Proc. Mal. Soc. Lon.*, vol. 2, pt. 5, p. 194, 1897, not of Adams and Angus.  
*Notoplax (Amblyplax) rubiginosus* Ashby, "Acanthoid Chitons N.Z." (*l.c.*)  
 Ashby figures a photo of the holotype and shows that it is an entirely different species from the preceding *foveauxensis*, with which it has hitherto been misidentified.  
 Type from Kapiti Island, West Coast, North Island, near entrance to Cook Strait, in the Dominion Museum..

**Notoplax (Amblyplax) mariae.**

- Acanthochites (Loboplax) mariae* Webster, *Trans. N.Z. Inst.* vol. 40, pp. 254-255, pls. 20, 21, figs. 1-11, 1908.  
*Acanthochites (Craspodoichiton) mariae* Iredale, *Proc. Mal. Soc. Lon.* vol. 9, pt. 2, p. 102, 1910.  
*Notoplax (Amblyplax) mariae* Ashby, "Acanthoid Chitons N.Z." (*l.c.*)  
 Ashby figures photos of paratype and gives full description.  
 Type from Orua Bay, Manukau Harbour; on rocks at low tide. In the Webster collection.

**Notoplax (Amblyplax) mariae stewartiana.**

- Loboplax stewartiana* Thiele, *Rev. des Syst. der Chitonen*, p. 37, pl. 5, figs. 8-12, 1909.  
 Iredale (*l.c.*) considered this species to be conspecific with the preceding.  
*Notoplax (Amblyplax) mariae stewartiana* Ashby, "Acanthoid Chitons of N.Z." (*l.c.*)

Ashby figures photos of the holotype which was lent for the purpose by the Museum d'Histoire Naturelle, Paris, and gives full description of same. Type from Stewart Island. In Mus. d'Hist. Nat. Paris.

**Notoplax (Amblyplax) mariae haurakiensis.**

*Notoplax (Amblyplax) mariae haurakiensis* Ashby, "The Acanthoid Chitons of N.Z." (l.c.)

Ashby gives full description and figures.

Type on *Atrina* shell in 20fms. Hauraki Gulf, dredged by Brookes. Presented to Auckland Museum.

Genus **CRYPTOCONCHUS** Burrow 1815.

Having tegmentum reduced in all valves to a linear ridge, insertion-plates broad, anterior valve 5 slits, median valves slits 1/1, posterior valve several slits, girdle leathery, naked, bearing 18 hair-tufts gills extending along the posterior half of foot.

*Cryptoconchus* Burrow 1815, *Elem. Conch.* 1815, p. 190. Type *Chiton porosus* Burrow.

**Cryptoconchus porosus.**

*Chiton porosus* Burrow, *Elem Conch* p. 189, pl. 28, fig. 1.

*Acanthochites (Cryptoconchus) porosus* Pilsbry, *Man. Conch.* 15, pp. 35-37, pl. 3, figs. 57-62; *Proc. Mal. Soc. Lon.*, p. 193.

*Chiton monticularis* Quoy and Gaimard, *Voy. Astrol.* 3, p. 406, pl. 73, figs. 30-35, 1825.

*Cryptoconchus stewartianus* Rochebrune, *Bull. Soc. Philom.* Paris, 1881-1882, p. 194.

*Chiton zealandicus* Quoy, Hutton, *Trans. N.Z. Inst.*, 4, 183, not of Q. and G.

*Cryptoconchus (Acanthochites) porosus* Wissel, *Zool. Jahrb.* 5, 319; (*op. cit.*), 20, p. 618, 1904 (anatomy).

*Cryptoconchus* Thiele (l.c.) p. 109.

*Cryptoconchus porosus* Iredale, *Trans. N.Z. Inst.*, vol. 47, 1914, p. 425.

*Cryptoconchus porosus* Ashby, "Acanthoid Chitons of N.Z." (l.c.)

Ashby figures photographs of co-type of Rochebrune's *C. stewartianus*, in Ashby collection, and gives a description thereof.

Genus **LOPHOPLAX** Ashby, 1926.

This provisional genus has been formed for the reception of a minute and unique example in which the tail-valve is missing, described under the name *Lophoplax finlayi* Ashby.

ACANTHOID CHARACTERS.

- (1) The girdle possesses hair-tufts at the sutures and in front of the anterior valve.
- (2) The anterior valve has 5 slits opposite the ray-folds.
- (3) In the median valve the insertion plate is well defined, slits 1/1, teeth sharp, neither festooned nor propped.
- (4) The girdle, except for hair-tufts, is clothed with minute, more or less circular scales, it also probably possesses a short marginal fringe.

## NON-ACANTHOID CHARACTERS.

- (a) The whole shell is very broad, very elevated and carinated.
- (b) The tegmentum is longitudinally narrow but very broad laterally, the sutural laminae are ischnoid in character.
- (c) The great size of the dorsal area, which is the shape of an equilateral triangle and the highly raised longitudinal ribs of the pleural area. The circular scales of the girdle more properly come here than under clause 4 above.

Type *Lophoplax finlayi*.

**Lophoplax finlayi.**

*Lophoplax finlayi* Ashby, "Acanthoid Chitons of N.Z." (l.c.)

Dredged off Otago Heads in 60fms.; valves figured. In Finlay collection, Dunedin.

## Genus PSEUDOTONICIA, 1926.

Characters described at commencement of this paper.

**Pseudotonicia cuneata.**

*Tonicia cuneata* Suter, *Trans. N.Z. Inst.* vol. 40, pp. 360-361, pl. 28, figs. 1-2, 1908.

*Craspedochiton cuneata* Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 425, 1914.

Ashby in "The Acanthoid Chitons of N.Z." (l.c.) gives reasons for its non-inclusion in the Subfamily Acanthochitoninae.

Full description and figures given earlier in present paper.

Type in Suter collection, in Wanganui Museum.

## INCORRECTLY PLACED IN GENUS ACANTHOCHITON.

**Mopalia australis.**

*Mopalia australis* Suter, *Proc. Mal. Soc. Lon.* vol. 7, p. 215, pl. 18, figs. 12-12a, 1907.

*Acanthochiton australis* Iredale, *Trans. N.Z. Inst.* vol. 47, p. 425, 1914.

Ashby in "The Acanthoid Chitons of N.Z." (l.c.) comments as follows: "I have not had the opportunity of seeing the type, but the drawings, accompanying Suter's description, show that it has 8 very distinct slits in the insertion-plate of the anterior valve, instead of the Acanthoid 5 slits, this entirely prevents its being placed in the genus *Acanthochiton*. The few setae mentioned by Suter as occurring on the girdle are probably mopalioid in character, rather than acanthoid, and I do not see any reason for removing this species from the *Mopaliidae* under which family Suter places it." I admit it may not belong to the genus *Mopalia* s.s."

ACANTHOID SPECIES INCORRECTLY REFERRED TO  
NEW ZEALAND.**Acanthochiton jucundus.**

*Acanthochites jucundus* Rochebrune, *Bull. Soc. Philom. Paris*, 1881-1882, p. 194.

*Acanthochites bellignyi* Rochebrune (l.c.), 1883-1884, p. 37.

*Acanthochiton jucundus* Ashby, "Acanthoid Chitons N.Z." (l.c.)

As this species is a near ally to several of the Dominion shells, I will quote from my paper (*l.c.*): "Through the kindness of Dr. Ed. Lamy, Paris, I have been enabled to compare a median valve of the holotype of *jucundus* with the New Zealand *Acanthochitons*. The median valve of *jucundus* is decorated with extremely even-sized, circular, raised, convex granules, and the dorsal area shows in the non-eroded portion, at sides and towards the apex, deep longitudinal grooving. It differs from *zealandicus*, *doubtlessensis*, and *thileniusi* in having longitudinally grooved dorsal area; from *brookesi* and the three above named in the flatness of the shell and its smaller, circular granules, it is nearer to *zealandicus* s.s. in the shape of its granules, but in *jucundus* they are more circular; I do not consider it a Dominion shell, and probably the locality of New Caledonia, given for *bellignyi* is correct." Now the rediscovery of *thileniusi* has made it desirable to review the above in face of the distinct grooving of the dorsal area of that species. I find that the grooving in this area in *jucundus* is coarser, and riblets do not show, the rugose and wavy sculpture of that species, the granules in *jucundus*, as before noted, are circular, about 75 to 87 mmm. in diameter, whereas in *thileniusi* they are fully one-third longer than wide and the granules near the dorsal area are twice as long as wide; in *jucundus* the granules are consistently circular and of small size throughout. The only qualification I have to make in the description quoted from my earlier paper, is that the convexity of the granules referred to is slight only and may not be a persistent feature. Type in Mus. d'Hist. Nat. Paris.

### ***Acanthochiton tristis*.**

*Acanthochites tristis* Rochebrune (*l.c.*) 1881-1882, p. 194.

*Acanthochites tristis* as being conspecific with *thileniusi* Iredale, *Proc. Mal. Soc. Lon.* vol. 9, p. 155, 1910.

*Acanthochiton tristis* Ashby in "Acanthoid Chitons of N.Z." (*l.c.*)

That Iredale's surmise that this species is conspecific with *thileniusi* is without any foundation, will be clear from the following notes which I quote from the earlier paper: "Again I am indebted to Dr. Ed. Lamy for the opportunity of comparing a median valve of Rochebrune's holotype, with the New Zealand species. This median valve is nearest to *mariae* and *stewartiana*, but the shell is more arched and the sculpture less elongate, but it is still more easily separated from any known *Acanthochiton*, by its distinctive dorsal area, which in *tristis* is narrow and quite smooth, except for broad, transverse growth ridges. This cannot be considered a New Zealand shell." Type in Mus. d'Hist. Nat. Paris.

### ***Spongiochiton productus*.**

*Spongiochiton productus* Carpenter, 1873. *Dall. Proc. U.S. Nat. Mus.* 1882, pp. 272, 283, 286, 289, 290.

*Spongiochiton productus* Pilsbry, *Man. Conch.* vol. 14, pp. 26-7; vol. 15, p. 7.

*Spongiochiton productus* Thiele (l.c.), p. 36, pl. 5, figs. 4-7; (l.c.), p. 199, considers *Spongiochiton* = *Loboplax*.

*Acanthochiton carpenteri* Pilsbry (l.c.), vol. 15, p. 35, pl. 1, figs. 14-22.

*Craspodoichiton productus* Iredale, *Proc. Mal. Soc. Lon.* vol. 9, pt. 2, p. 101.

Ashby in "Acanthoid Chitons N.Z." (l.c.) says: "In looking at the figures and descriptions I independently came to the conclusion that *Spongiochiton productus* is near to *Notoplax* (*Amblyplax*) *foveauxensis* Mestayer, in fact it might be that shell."

Iredale pointed out that Carpenter's drawings of the type are labelled "from Port Elizabeth, South Africa," whereas the specimen seems to have been attributed to New Zealand; on these grounds he considered that it was not a New Zealand species. Until some facts are produced to the contrary I think we may well adopt this course."

## PHYLOGENY.

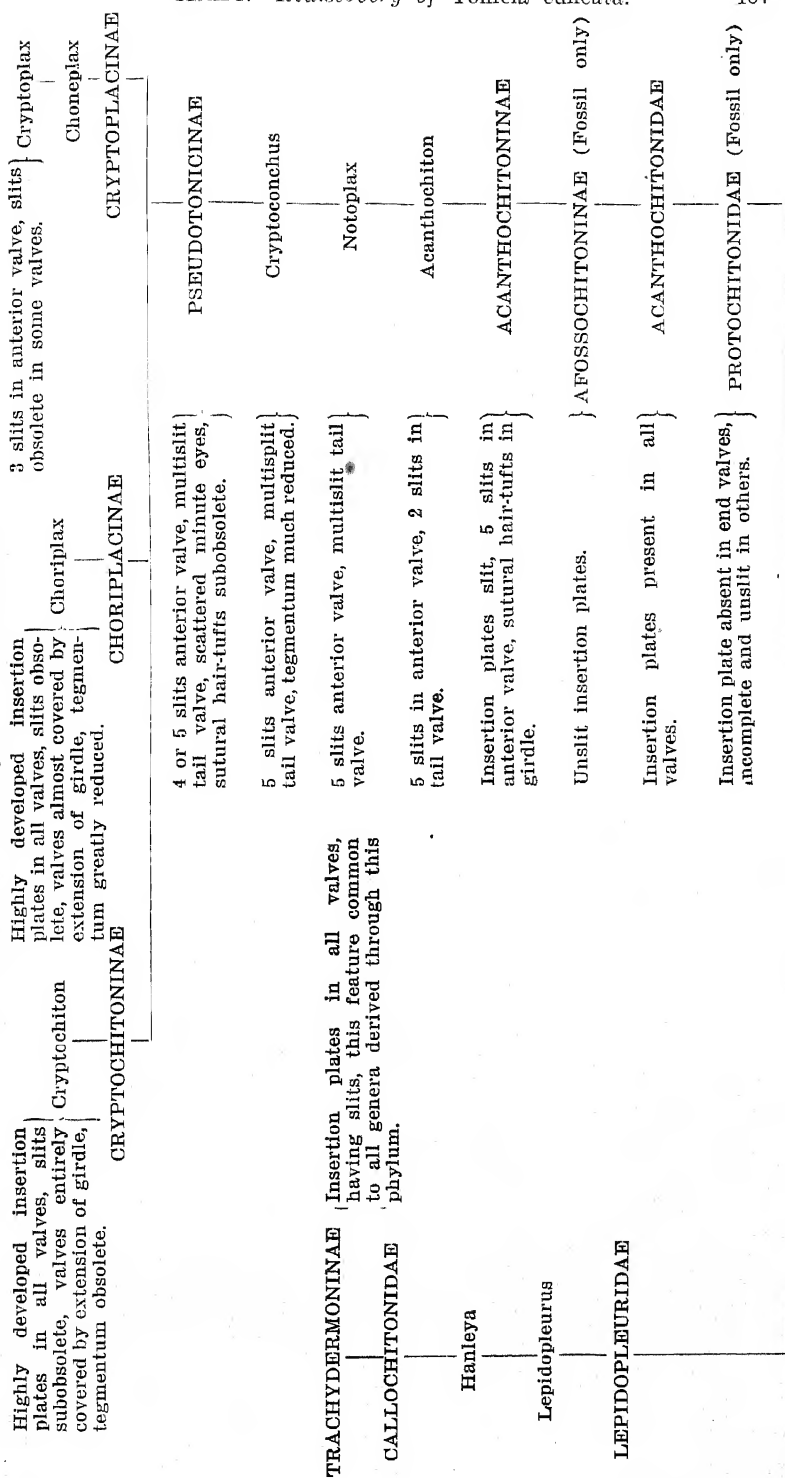
I have no hesitation in repeating a statement made in an earlier paper. The hypothesis that the modifications in the insertion-plates of Polyplacophora are due to the influence of ecological conditions over vast periods of time, and that these characters give us the best guide to the species proper place in the Natural Taxis, is increasingly substantiated the more I study this group of Mollusca. I am therefore the more willing to place confidence in those divisions that are based on such features.

In my "Monograph on Australian Fossil Polyplacophora (Chitons)" *Proc. Roy. Vict.* vol. 37 (n.s.) pt. 2, pp. 170-205, pls. 18-22, figs 1-36, I suggest that living Chitons have been evolved along two (at the least) distinct, parallel lines, having come to this conclusion as a result of my investigations in Australian Palaeontology. Up till the publication of the said paper it has generally been accepted that the Palaeozoic forms disappeared somewhere about the Jurassic, or earlier and the type that occur in later Secondary and Tertiary rocks are quite distinct, being the direct progenitors of living forms.

Owing to recent discoveries in the Oligocene (Balcumbian) rocks of Victoria, I suggest that my new genus *Protochiton* forms one of the most important missing links and consider this species the progenitor of the Phylum Acanthochitonidae, that family having been derived from Palaeozoic stock along this line and not through the family Lepidopleuridae at all.

The genus *Lepidopleurus* has heretofore been considered the most primitive of all living forms, but it seems certain that the genus *Protochiton* cannot be derived from any member of that genus, for while some of its characters seem less primitive, others suggest an affinity with the Palaeozoic group, which does not exist in the Lepidopleuridae; I submit a Phylogenetic Diagram which will better express my views in this relationship.

# PHYLOGENETIC DIAGRAM.



PALAEOZOIC CHITONS.

## The Geology of View Hill and Neighbourhood.

By R. SPEIGHT, M.A., M.Sc., F.G.S., F.Am.G.S.

[*Read before the Philosophical Institute of Canterbury, 3rd November, 1926; received by Editor, 21st September, 1927; issued separately, 14th February, 1928.*]

(PLATE 41.)

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    - c. Starvation Hill.
    - d. Burnt Hill.
    - e. Occurrences in the Waimakariri.
      - (1) Browns Rock.
      - (2) Rockford.
      - (3) Woodstock.
    - f. Greywackes.

### A. INTRODUCTORY.

The neighbourhood of View Hill presents several points of geological interest. Within a radius of six miles from the hill itself, there are several inliers of Trias-Jura, Cretaceous, and Tertiary rocks, cropping up through the gravels of the plains, while lying on the western spurs of Mount Oxford occurs an interesting deposit of chalk with associated greensands and basic volcanics. Haast has made brief reference to View Hill and Burnt Hill (1879, p. 282). Hutton has referred to Gorge Hill on the Waimakariri (1877, pp. 56-7. and 1885, pp. 49-53), to View Hill and Burnt Hill (1877, p. 41); and McKay (1881, pp. 40-53) and Wilson (1888, pp. 274-276) have referred to the chalk deposit. I have found McKay's account exceptionally accurate considering the fact that the country was covered with bush when he reported on it. He had the advantage all the same of being able to see the chalk quarry when it had been opened

out, whereas it is now difficult to find the exact spot where it was. McKay's statements are used as the basis of the account of the chalk deposit given in Bulletin No. 22 of the New Zealand Geological Survey (1919, p. 234). There is also a brief reference to the locality in Palaeontological Bulletin No. 11 (1926, p. 12) where Chapman gives a list of the foraminifera found in the chalk.

With this brief introduction I will proceed with the description of the geological features of the district, taking each particular locality in turn commencing with the name locality, View Hill.

## B. VARIOUS OCCURRENCES.

### 1. *View Hill.*

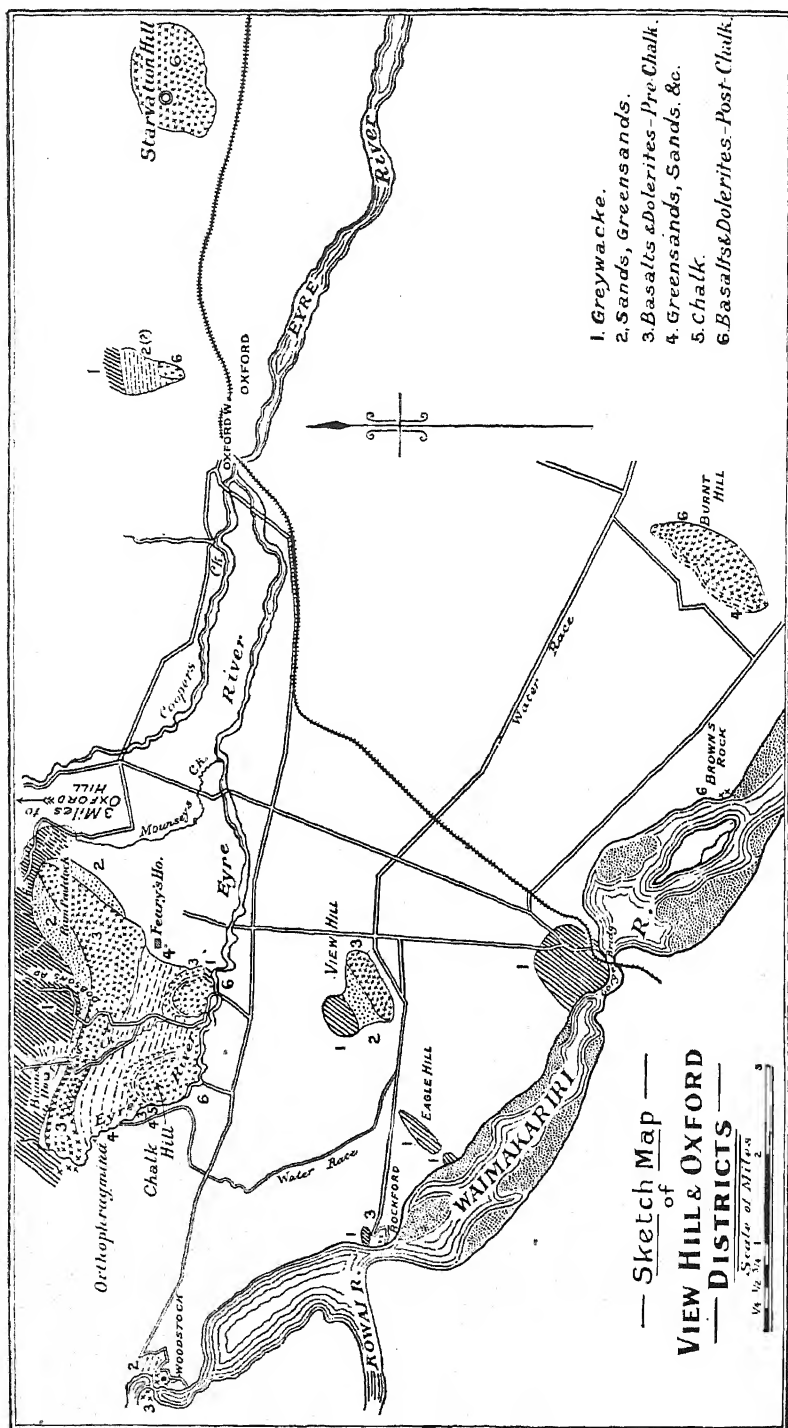
This elevation lies about two miles due north of the Waimakariri Gorge Bridge and rises to a height of 1231ft. above sea-level, or about 250ft. above the general level of the plains in the neighbourhood, which average about 1000ft. The hill is a double one with two well-defined summits, separated by a low tract of country eroded on weakly-resistant rocks. The eastern hill is the higher of the two, and it takes the form of a ridge, steep on the north-west side but more gentle on the south-east. The western hill shows subdued landscape features, and its south-eastern slope is evidently part of a stripped surface of greywacke. On this rest unconformably sandy shales, well laminated, with thin layers of carbonaceous material, dipping south-east at angles of from  $5^{\circ}$  to  $10^{\circ}$ . Over these lie sands which have been indurated in places by the capping of dolerite,\* but the actual contacts cannot be seen owing to the covering of soil and slip material. The dolerite is continuous along the top of the ridge, and the capping is formed of flows dipping south-east. Its texture is frequently coarse, and it is then singularly susceptible to weathering agents, so that fresh samples are difficult to obtain. At times it is markedly vesicular. The general circumstances of the rocks point to their being flows and not intrusions, and in all probability there are several flows present as in the case of the occurrences at Burnt Hill, to be described later—and along the Harper Hills and Homebush Ridge in the Malvern district; but in the absence of any clear exposures of the overlying beds this point cannot be settled for certain. Although chalk has been reported as coming from View Hill itself, I have seen no sign of it on the hill, so I think confusion has arisen between the name of the hill and the name of the district, which extends across the Eyre River to the north.

### 2. *Eagle Hill.*

The greywacke surface of View Hill no doubt extends towards the south-west under the gravels of the plains, for greywacke appears again on the banks of the Waimakariri in an eminence known as Eagle Hill, and on the flanks of the terraces extending south-west therefrom towards the bed of the river. The rock exposed is everywhere a hard greyish greywacke, and it has an apparent strike in a north-east direction. Like View Hill the steep slope of this hill faces north-west.

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\*The term "Dolerite" as used in this paper means a coarse-grained basalt.



### 3. *Rockford.*

About a mile further up stream, just below the junction of the Kowai with the Waimakariri, is a spot known as Rockford, from a crossing of the river near a greywacke rock standing up in the middle of the stream. A similar rock occurs on the floor of one of the lower terraces, and in close proximity to it is a small exposure of dolerite. The true extent of this cannot be determined owing to the mask of gravel, but it is similar in texture to that at View Hill.

### 4. *Woodstock.*

Close to Woodstock Homestead, in the precipitous banks of the Waimakariri, is an occurrence of greensand associated with basalt. This lies almost opposite to the occurrence of sands exposed on the right bank of the stream near Otarama containing *Conchothyra parasitica*, which is the place of origin of the specimens of this shell described by Hutton. The greensands probably belong to the same occurrence. They are deep green in tint, very glauconitic, somewhat coarse in texture with grains of quartz clearly visible to the eye. The sands contain small fragments of shells, but little can be said definitely about the whole occurrence because it cannot be properly examined owing to the dangerous nature of the banks of the river at the spot. The basalt with which the sands are associated is fine-grained amygdaloidal especially near the lower margin, with numerous veins of crystalline calcite, much jointed, dark in colour, and apparently resting on greensand, not intrusive into it. At the only contact visible it rests against a bank of greensand, which may be a fault-contact, though the probability is against such being the case. The basalt forms the projecting portion of the terrace, and protects the easily eroded greensand from the erosive action of the stream.

### 5. *Browns Rock.*

About two miles below the Gorge Bridge a point stretches out into the bed of the Waimakariri buttressed on the end by a mass of basic volcanic rock. The exposure is a very small one, extending for about a couple of chains in the north side of the point, and about a chain facing the direction of the main stream. It is covered by gravels and no exposures of associated sedimentaries other than the gravels are visible, so its relations cannot be determined. As will be pointed out later its lithological characters are those of the latest occurrences of volcanic rocks in the area.

It furnishes an excellent example of such a mass acting as a ledge defending terraces formed by re-excavation, according to the principles of Miller and W. M. Davis (see *Amer. Journ. Sci.* vol. 14, 1902. pp. 77-94). The same applies to the rocks, both greywacke and dolerite, at Rockford, although they do not act as perfectly in the manner indicated as those at Browns Rock.

### 6. *The Eyre River.*

#### a. *General Stratigraphy* (See Sections A, B, C).

This is the most important occurrence in the district, not only from its intrinsic interest but from the extent of the country covered by the beds. The area stretches in an easterly direction along the

base of the southern and south-western slopes of Mount Oxford from the gorge of the Eyre River, a distance of nearly four miles. The western boundary follows along the main Eyre for about three miles, while the width narrows to practically a point on following the beds eastward.

The country for which these beds are the basis consists of downs which rise above the plains to a maximum of about 500 feet, and which have suffered dissection by the Eyre and its tributaries, the directions of the chief ridges being determined by the lines of outcrop of the igneous rocks. Wherever observed the beds have a dip to S.S.W. at low angles, so that the scarps as a rule trend approximately east and west.

The chief tributaries of the Eyre coming in from this area are Whites Creek, which runs across the strike in the western part and Mounseys Creek which runs east along the line of junction of the greywacke for a distance of two miles, on for a further distance of two miles in greywacke, and then turns at right angles and flows south to join the main Eyre River. The upper part of this creek is bounded on the north by a stripped surface of greywacke and on the south by a flattish area, known as the Ram Paddock, which stretches towards the south to an east and west scarp formed out of lava-flows with a gentle southerly dip. There is also a tendency to develop subsequent streams, other than these, in the soft beds between the lava-flows, and the low gap behind Mr. Feary's homestead may be attributed to this action.

Although the scarps are moderately well defined good exposures are rare, the best being found on the banks of the Eyre River and the hillsides adjacent thereto. These will be dealt with first.

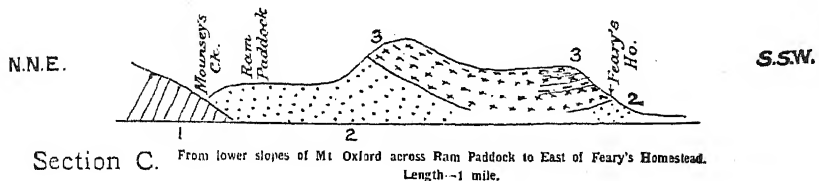
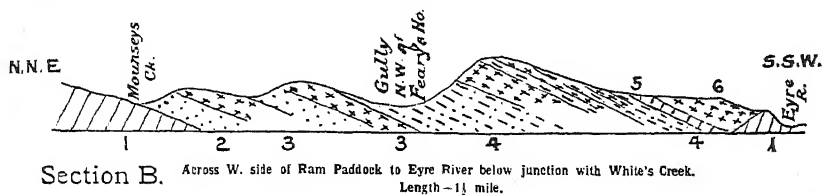
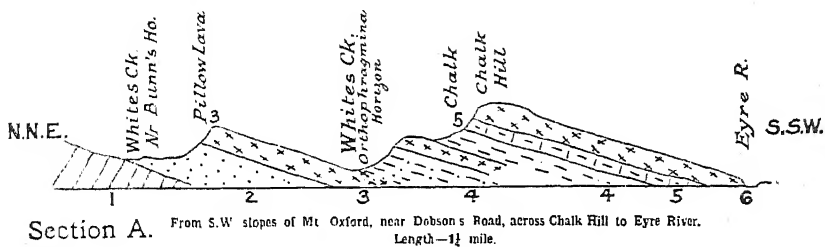
Following down this river from the greywacke gorge, the banks are obscured for nearly half a mile; then occurs a sheet of basalt about 25ft. thick lying over greensand, striking E. 25° S and dipping approximately S.S.W. at an angle of 10°. This basalt is amygdaloidal, and exhibits on the outcrop signs of pillow structure. It can be traced across the ridge between the Eyre and Whites Creek, the next tributary to the east, and on into the bed of this stream where it has been quarried for road metal. On the crest of the dividing ridge it is separated by but a small distance from the outcrops of greywacke. I was not able to trace this basalt to the west of the Eyre although a well defined bush-clad ridge appeared in alignment with it, but no outcrops of basic rock or boulders of basic rock were seen, although greywacke boulders were plentiful.

Another ridge lying parallel to this and more to the south-west is composed entirely of greywacke, but lying on it occurs one of the cherty masses associated with the basalt in this area, to be referred to more particularly later, and this probably indicates an extension of the basic rocks to the west of the Eyre.

On the terrace just above the outcrop of basalt on the left bank of the stream, there are a fair number of these blocks lying on the surface, suggesting that the bed from which they have been derived was once in close proximity. These masses are similar to the quartzose blocks which lie on the surface of the schists of Central

Otago, formed by the cementation of quartz sands, and are locally known to the miners of that district as "chinamen."

About 300 yards below the junction of the tributary of the Eyre coming in from the west, and just below the old ruined homestead and yards, the river is crossed diagonally by a sheet of pillow-lava; owing to the bending of the course of the river it is intersected twice. The lava rests on a greenish-grey, slightly glauconitic, non-calcareous sand, while overlying it are calcareous ash-beds containing *Ortho-phragmina*. The general strike of all these beds is approximately east and west, almost parallel to the general trend of the river in that part of its course. The outcrops occur here in places over a length of about 200 yards. The occurrence is important, as it clearly indicates the presence of pillow-lava at two levels in the greensand.



- |  |                                      |                        |
|--|--------------------------------------|------------------------|
| 1. Greywacke.                            | 2. Sands passing up into Greensands. | 3. Basalts—Pre-Chalk.  |
| 4. Greensands passing up into Sands, &c. | 5. Chalk.                            | 6. Basalts—Post-Chalk. |

#### SECTIONS ACROSS THE EYRE RIVER TERTIARY BEDS.

These sections are taken across the strike from the slopes of Mount Oxford towards the Eyre River, and give a diagrammatic representation of the lie of the beds. It is impossible to represent on such a small scale all the occurrences of basalt that occur in the sands below the chalk, and those that are given must be taken as representative merely.

Further down stream, about 200 yards above the intake of the water-race, is an occurrence of much decomposed ash on the right bank of the Eyre. This outcrops in places over a length of 100 yards.

Then comes the ridge which I have called Chalk Hill for convenience of reference. The rocks outcropping on the extreme north-western end of this ridge are doleritic in character, and form a well-

defined shelf which can be traced down on the eastern flank of the ridge towards Whites Creek. The summit of the ridge consists of dolerite, and beneath it lies the chalk, which can be seen in very few places owing to the covering of soil, but it can be traced down into the bed of the Eyre, where there is an exposure of the beds over a length of about two chains. The sequence from below upwards is as follows:—

1. *Basalt and ash-beds*, of uncertain thickness.
2. *Sands*, bluish-grey in colour, non-calcareous, with yellow powdery efflorescence, (? sulphur), and smelling of sulphur; 12 to 15 ft. thick.
3. *Greensand*, markedly glauconitic, 12 to 15 ft. thick.
4. *Chalk*, somewhat marly in character, flaky in texture, 15 to 17 ft. thick.
5. *Dolerite*, following on apparently conformably, but the actual contact is obscured, and for 6 in. the underlying bed could not be seen, and the junction was filled with clay. There is no sign of alteration in the chalk beyond this obscurity.

On the hillside above the stream flints appear plentifully, and in some cases they form well-defined layers in the chalk extending on the surface of the ground for over 2 chains. Just above the exposure in the Eyre the dolerite has been quarried to make room for a bush road, and some of the stone has been used for metalling. In the quarry columnar structure is well developed, and the columns show well marked constrictions across their length, producing an appearance which may be called a "concertina" effect. The ribs so formed appear to be associated with cross cracks due to shrinkage in length, for the rock in their immediate vicinity is closer grained and more resistant to weathering.

Basalt occurs all along the slope of the ridge facing the Eyre River and probably indicates flows at various levels, separated by layers of ash or of fragmentary material, although the latter are not apparent. The river follows round the base of the ridge, and there are signs of the development of valleys in the softer beds and the cutting through of the harder capping in places, so that the underlying weaker beds are attacked. Owing to the absence of clear sections it is difficult to say whether or not this is actually the case, or whether the hollows are partly due to synclinal folding of the lava-flows. Such modification of the beds occurs lower down the Eyre, and perhaps sympathetic structures occur on the western and southern facing of the hill above the junction of Whites Creek.

Whites Creek runs more directly across the strike of the beds, and the banks on either side furnish the most complete record of events that have occurred in the area. The greywackes form the basement beds, and are well exposed in the upper part of the creek. They are of the slightly-coarser definitely grey type, and I could not find any trace of the diabase ash recorded by McKay (1881 p. 53.) as occurring near the chalk deposit, although it occurs more to the eastward on the slopes of Mount Oxford in the vicinity of Coopers Creek. It is thus midway between the occurrences in the Ashley Gorge and those on the southern side of the valley of the Hawkins River in the Malvern area.



Pillow lava, Whites Creek. Showing ovoid masses, with glassy selvages and cuboidal and prismatic jointing.



The clearly exposed covering-beds are greensands, which are followed somewhat closely by pillow-lava. The former are exposed in the bed of the creek just below Mr. Bunn's homestead, and the latter close alongside in a quarry used for procuring road-metal, the structure of the rock being clearly seen in the workings. (Plate 38), Ovoid masses up to 3 feet in diameter, characteristic of pillow-structure, are well developed, and the spaces between them are filled by smaller spheroids. They break up into more or less cuboidal or prismatic blocks of small size, up to about 6 inches in length. The outside of each pillow is formed of a thin selvage of glassy material as if the rock had been suddenly chilled. The general mass of the rock is close grained but is in places full of small steam-holes and then again of larger ones several inches in length. The latter are usually filled with amygdulæ of calcite, but in some of them chalcodony is the filling material. In the spaces between the pillows occur masses of chalcedonic quartz, which gives a feeble reaction to acid, showing that carbonates are also present.

In places, too, there are radiating masses of chalcodony, stained with iron oxide, with fibres or rods occasionally three inches in length and varying in thickness from one sixteenth of an inch up to nearly half an inch.

The pillow-lava and the underlying greensands strike E.S.E.-W.N.W., and have a southerly dip at moderate angles. The lava forms a well-defined scarp extending for at least half a mile in either direction, and on the northern face in several places the "pillows" lie weathered out on the surface of the ground. About a quarter of a mile to the east the decomposed material is exposed in a shallow cutting where the Dobson Road crosses the ridge.

The next exposure higher in the sequence is about three hundred yards further down the creek. Here the following beds occur:—

1. *Calcareous greyish sands.*
2. *Ash-beds* with a greyish matrix, containing angular pieces of volcanic material.
3. *Finer grained ash-beds* with cuboidal fracture, calcareous.
4. *Calcareous sands*, greyish in colour.
5. *Calcareous ash-beds*, with many fragments of fossil shells the fragments of such small size as to be undistinguishable; markedly cross bedded.
6. *Glaucconitic sands*, distinctly calcareous.

These are capped with recent river gravels. The total length of this exposure does not exceed one chain, and the strike of the beds is towards the gap in the ridge behind Mr. Feary's house, where similar beds occur, as will be recorded later.

Further down stream there are occurrences of greensand, and then the beds developed in Chalk Hill. The first bed exposed overlying the greensand is a flow of lava which rises towards the north-west end of the hill and forms a definite shelf which marks the north-east facing of the ridge. Over this, perhaps, not directly, lies the chalk, fairly high up and close under the dolerite which caps the ridge. The chalk was formerly worked in two places, one near the point of the spur near

the junction of Whites Creek with the Eyre, about 100 feet above the level of the valley, and the other near the northern end of the ridge about 270 feet above that level. At present the workings are almost obliterated. The chalk is white or greyish white in colour; in places soft and earthy, but in others hard like limestone. This latter facies should on drying crush into powder tolerably well. Masses and fragments of flint occur freely in it. It is followed closely by a basic flow, and in parallel sequence, as far as can be judged though there is no evidence that the flow is submarine. If this is not the case, and the flow is subaerial, then it implies an erosion period between the deposit of the chalk and the extrusion of the volcanic rocks.

The thickness of the chalk is probably about 50 ft., but cannot be determined in any place with exactness. The strike is E.S.E.-W.N.W. as calculated from the heights and positions of three outcrops. This differs from the determination made by McKay.

On the eastern side of the creek the chalk does not appear at the surface, although I am told by Mr. Feary that it was seen in post-holes when fences were being run along the top of the ridge west of his house between Whites Creek and the Eyre River. However, in a slip there is a good exposure of yellowish-white quartz sand, slightly calcareous, which probably lies at lower stratigraphical horizon than the chalk, and there is at this horizon and at lower ones a great development of cherty masses, apparently interstratified with the basalt at various levels. There are no clear exposures, so that the problem of their precise relationship to the basalts must be left unsolved for the present.

The uppermost bed on the eastern side of Whites Creek near its junction with the Eyre is a coarse basalt or dolerite which covers ash. This has the usual dip, but round the corner in a downstream direction the beds are apparently bent up into a syncline with an axis extending a short distance in a north-easterly direction, and with its south-eastern limb resting on greywacke. This last is exposed in the bed and steep banks of the Eyre for a few chains, and it forms a small rounded hill acting as a buttress to the basalts and their associated beds at their most southerly extension towards the plains. This inlier of greywacke is close to that of View Hill, and in alignment with it and the outcrops of greywacke at Eagle Hill and its extensions towards the Waimakariri below Rockford.

The total thickness of the sands, greensands, chalk, and volcanics as developed in this section approximates 1200 feet.

The next section will be taken running approximately south across the area from the Ram Paddock to the Valley behind Mr. Feary's house. In Mounseys Creek the greywacke is exposed striking E.N.E. and with a northerly dip at high angles. It forms a striped surface extending up the slope to the north. On this, as far as can be seen, rests unconformably the following sequence, from below upwards:—

1. *Sandy Clays with impure shale*, striking along the creek, that is, E.N.E. and with a southerly dip at low angles.
2. *Sands*, yellowish-white in colour and weathering brown.
3. *Sands*, greenish-grey in colour, in places definitely green.
4. *Basalt*, probably dipping S.S.W.

For some distance there are no exposures, and then the sequence is resumed with

5. *Ash-beds.*

6. *Basalt*, capping the ash, and exhibiting pillow structure, probably connected with the pillow-lava in Whites Creek.

7. *Greensands*, exposed in the creek behind Mr. Feary's house.

8. *Calcareous Tuffs*, current-bedded, with a southerly dip, like those in Whites Creek.

Then follows a succession of basalt flows with cherty beds interstratified, at least three in number and perhaps more, the uppermost bed of chert lying in all probability close under the chalk. This is capped by lava-flows, whose ends are truncated by a steep slope facing south-east as if a fault ran along and determined the edge of the downs in that direction.

This area of associated volcanics and sedimentaries extends north-east and forms the ridge between Mounseys Creek and the plain. I did not see it across the creek, though it is possible that small isolated outliers may exist lying on the greywacke surface. In this portion of the area the exposures are not clear, but it is evident that there is the same succession of beds as elsewhere. Sands form the lowest member of the more recent sequence; sometimes these are concretionary in character, and interstratified with them are fine-grained basalts similar in external appearance to the pillow-lavas in Whites Creek; over the lavas lie sands which in many places are concretionary, and these are succeeded by greensands, which are best exposed in the gully behind Mr. Langer's house and in the bush lying south-west of it. To the north of the house concretionary sands are well developed, probably higher in the sequence than the greensands. On the western side of this bushled gully there is a good exposure of concretionary greensand. I saw no fossils in this, and I could get no exposure which enabled the dip to be determined with accuracy, but it is probably towards the south-west in agreement with the slope of the basement surface of greywacke, although there are some indications that it may be bent up into a syncline with an axis running N.E.-S.W.

Over these sands there is a regular succession of basalts of coarser texture with interstratified masses of cherty rock. These are repeated several times as the beds are followed to higher levels, but no clear exposure showing the relations of the sedimentaries to the volcanics could be discovered, although the whole country was carefully examined.

A somewhat interesting occurrence was observed in the gully just east of Mr. Feary's house.

Here there are volcanic ash-beds interstratified with flows, the former striking N.E.-S.W. and dipping N.W. at an angle of 30°. The ash-beds are 50ft. thick and consist of fine material with angular volcanic fragments up to 2ft. in diameter, though they are mostly small, 2 to 3 inches in diameter. Some beds are slightly calcareous. On the ridge to the north-west are flows lying fairly flat or dipping slightly west, while there are cherty masses on the ridge to the north-east divided from the ash-beds by at least one flow of basalt.

The thickness of the volcanic rocks, and the number of flows existing, are apparently greater in this part of the area than in any other, but no actual centre has been located from which the flows might have come; and they resemble in that particular the other occurrences of Tertiary volcanics that fringe the base of the mountain area of Canterbury. Whether or not these represent some form of fissure eruption or whether the actual centres lie buried under the gravels of plains cannot be determined at present.

6. *The Chalk Deposit:* It is unfortunate that there are so few exposures of Chalk at the present time. When it was referred to by McKay and Wilson the pit was being worked, but now one can hardly see where it was located. The composition of the chalk is very variable from place to place. It is occasionally very argillaceous and again a fairly pure calcium carbonate. Wherever exposed it was found to contain nodules of flint, and at times layers of siliceous material.

Analyses made in the Dominion Laboratory are as follows;—

Matters insoluble in acid	.....	.....	15.69	32.10
Alumina	.....	.....		0.92
Iron Oxides	.....	.....	Traces	Traces
Calcium Carbonate	.....	.....	82.26	86.82
Magnesium Carbonate	.....	.....	1.84	
Water	.....	.....	0.21	0.16
			<hr/>	<hr/>
			100.00	100.00

The matter insoluble in acid must be largely siliceous material.

The examination of the chalk in a section under the microscope discloses that it is composed of an irresoluble base in which can be seen very clearly remains of the tests of foraminifera; sometimes these are almost perfect. There is as well a considerable amount of glauconite in grains, as well as very small fragments of quartz, distributed quite freely through it.

The flint presents certain features of interest. The fact that it occurs at times in definite layers rather supports the hypothesis that it may be the result of chemical precipitation and not an organic deposit.

The only signs of organisms are the remains of foraminifera, similar to those in the calcareous material, which have been silicified and retain their form in that state. Under the microscope there appears to be just about the same proportion of glauconite as appears in the chalk, and there are as well numerous grains of quartz, and occasional flecks of mica, distinguished from the glauconite by their stronger pleochroism and lower extinction angle. These minerals occur in a groundmass which is irresoluble, but which has a higher index of refraction than balsam. In the hand specimen the flint presents a smooth resinous appearance, a conchoidal fracture, and in some instances a colour which is brownish to honey-yellow, and where exposed to the atmosphere takes on the surface-appearances which may be called "desert varnish."

This deposit is referred to by Chapman in his report on the Foraminifers of New Zealand (1926, p. 12) where he gives the list of the forms occurring therein and classifies the age as Upper Cretaceous, i.e. Danian, the age being the same as that of the Amuri Limestone as it occurs in various parts of North Canterbury from Kaikoura, through Amuri Bluff, and Weka Pass to the Waipara. He states that the marls of the Broken River area which have sometimes been correlated with the Amuri Limestone belong to a slightly higher horizon, viz. Eocene.

Previous to the present examination of the country the only definite evidence of age was that based on Chapman's determination of the foraminifera. McKay records the reported discovery of a shell of *Conchothyra parasitica* in the bed of the Eyre River, and presumably it came from the strata underlying the chalk, a presumption strengthened by the association of beds containing *Conchothyra* with greensand in the Waimakariri, a comparatively small distance away, and striking in the same direction as the greensands in the Eyre.

Wilson (1888, p. 275) reports the occurrence of *Pecten williamsoni* and *P. fischeri* in the chalk, and a specimen of the former marked as coming from Oxford, and with a matrix similar to that of the chalk as found in the bed of the Eyre, occurs among the fossil shells of the Canterbury Museum. The discovery of these shells does not materially aid in the determination of the age of the beds, and as there was some doubt about their identification I submitted the specimen in the Museum to Dr. J. Marwick, Palaeontologist to the New Zealand Geological Survey, and he writes as follows:—"I have compared the Oxford *Pecten williamsoni* with topotypes of that species. The Canterbury shell has a similar number of ribs, but is considerably smaller. Also the apical angle is much less than in true *williamsoni* and the shape is different. Of course the Museum specimen may be a juvenile, but even granted that I do not think it should be classed as *Chlamys williamsoni*. As it is only an internal cast I doubt if it can be used for any reliable correlation, but the general appearance and preservation suggest a Tertiary age."

The discovery of *Orthophragmina* at a lower stratigraphical horizon than the chalk bed—approximately 600ft. below it—in a position where faulting on a major scale appears impossible, adds a new interest to the problem. Wherever *Orthophragmina* occurs in Europe or America it is regarded as an Eocene form, so a revision of the age of the chalk appears necessary. If the beds containing *Orthophragmina* be regarded as Eocene this would enable a correlation of these beds to be made with those in the Trelissick basin, classed by Chapman as Eocene (1926, pp. 14-15), and then the sequence of the beds near the Eyre would fit in with those of the Trelissick where the marls are underlain with sands, greensands, sands, beds containing *Conchothyra*, etc., and clays and shales with coal, in descending order, just as the chalk bed near the Eyre is underlain by a similar sequence, except that the *Conchothyra* is wanting, although it does occur at Woodstock apparently under greensand. I am sorry that the difficult nature of this locality renders it practically impossible at

present to say what are the precise relations of the greensand near the Woodstock homestead to the shell bed a little higher upstream across the river. All the same, they may be conformable below the greensand just as they are in the Trelissick basin.

There is besides a difference in the general facies of the sedimentaries near the Eyre from that of the classic locality at the Waipara and at Malvern, which throws some doubt on the chalk being Cretaceous in age. The Saurian beds, the black-oyster bed, and the concretionary sands characteristic of these areas just mentioned, where the beds are definitely Cretaceous, are absent from the Eyre locality, and this absence requires some explanation if the occurrence there is considered to be Cretaceous. It seems therefore to be best to follow the conclusion based on the presence of *Orthophragmina*, that the beds are Lower Tertiary in age. However, if Chapman's correlation of the chalk at Oxford with the Amuri Limestone of North Canterbury be correct, then the record of the presence of *Orthophragmina* below the chalk has an important bearing on the accepted age of the various beds in the Cretaceous to Tertiary sequence of the North Canterbury area.

C. *Volcanic Rocks*: The most interesting stratigraphical feature of the occurrence is the presence of flows of basalt at different levels. The lowest occurs in sands which are no doubt of Lower Tertiary age, and then pillow-lavas occur freely interstratified with greensand throughout a considerable thickness of beds under conditions which certainly suggest that they were submarine in origin, and in many cases too these lavas are interstratified with cherty layers, as is the case with so many pillow-lavas. In the higher parts of the greensand the pillow-facies disappears, although the evidence here also points to submarine eruptions and the presence of cherty beds.

Then follow flows underlying the chalk, which were no doubt submarine in origin, though they do not exhibit pillow-structure, the fact that they are underlain by marine beds and overlain by marine beds in parallel sequence rendering this almost a certainty. The bed overlying the chalk, though also apparently parallel, is probably subaerial. It exhibits no pillow-facies, and is comparable in every way, both mineralogically and texturally with the basalt closing the sequence of Burnt Hill, which is definitely post-Awamoan in age. As will be mentioned subsequently, the latest flows observable in any of those localities are hypersthene-bearing basalts or dolerites, and this points to a similarity in age, although it is not positive evidence that it is so.

A most interesting feature of the volcanic rocks is their association with cherty masses, which are probably cemented from sands interstratified with the flows. The pillow-lavas, however, are chiefly associated with greensands, whereas the quartz sands either occur at lower horizons than the volcanics or much higher in the sequence and at a level where pillow-lavas do not occur as far as can be seen. If it be taken that the chalk represents a deposit in water deeper than that at which greensand forms, then there may be some connection between the depth of water and the development of pillow-structure, but after all this may be only a coincidence and have no real bearing

on the occurrence of this much-debated feature. And then again the chalk may have been laid down in water shallower than that at which the greensand was deposited and so the pillow structure is conceivably due to deeper water conditions.

### 7. *Oxford.*

That this series of beds once extended round the base of the foot-hills of Mt. Oxford in an easterly direction is proved by the occurrence of a scoriaceous basalt, once used for road-metal, on the end of the spur immediately behind the West Oxford township. The rock is exposed in an old quarry and for a few chains on the eastern side of the ridge. There is no other outcrop of rock for about half a mile up the ridge, but the characteristic subdued topography, in contrast with that of the greywacke hills behind it, suggests that the end of the spur is formed of unresistant beds. This conclusion is supported by the evidence of Mr. Burrows, who owns the property and is an extremely old resident of the district, that fine white sand was met with in a shaft sunk to a depth of about 60 feet, four or five chains from the end of the spur, and also that a greensand was encountered in a well on the flat about three-quarters of a mile to the north-east and immediately alongside the ridge. Just behind this, greywacke is seen in position, forming an old stripped surface inclined to the south with the beds striking the N.E.-S.W. and dipping at high angles to the N.W. Mr. Burrows also states that scoriaceous beds were met with in sinking wells on the flat to the east of the end of the spur, in the direction of Starvation Hill, which lies about three miles further east. This occurrence near Oxford is thus a connecting link between the beds developed in the Eyre basin and the volcanics of Starvation Hill, to be referred to in the next section.

### 8. *Starvation Hill.*

This is a detached elevation lying about two miles east of the township of East Oxford, just north of the railway and rising about 250ft. above the level of the plain in its vicinity. The hill is almost completely grassed, or under cultivation, and the only exposures of rock occur on the southern face where, in the gullies, there are outcrops of basic rock separated in places by fragmentary material. As far as can be judged from the limited exposures, the flows dip north at very low angles. Finer grained facies predominate in the lower exposures and coarser in the upper, the latter being usually somewhat vesicular. There is a specimen in the Canterbury Museum from Starvation Hill labelled by Hutton as Tachylite Tuff, which is composed of very fine-grained basalt fragments cemented by calcareous material. I have not seen this material in position, and I expect it was obtained in the early days by Haast, when perhaps excavations were made which are now filled up. In any case it shows the close proximity of calcareous beds, and indicates the probable extension eastwards either of the beds near Oxford or the upper beds of Burnt Hill, which certainly do strike in the direction of Starvation Hill.

9. *Burnt Hill.*

a. *General Stratigraphy:* Burnt Hill is a Tertiary inlier rising through the gravels of the plains, about 6 miles S.S.W. of Oxford and 4 miles down stream from the Lower Waimakariri Gorge Bridge. It is a mile from the banks of the river. The trig. pole on the top is 1210ft. above the sea, and the level of the plains at the base approximately 700ft., so that it rises about 500ft. above the general surface. The hill forms a ridge about  $1\frac{1}{2}$  miles in length, sinking down to plain level at either end. The beds which determine its shape are basaltic lava-flows with a dip of about  $10^\circ$  to the south-east, on which side the slopes are gentle and accordant with the dip, while on the north-west facing they are steep and in some places precipitous.

As far as could be judged from exposures there are at least three definite flows of volcanic rock, and there may be more; a fairly complete covering of rich soil masks the south-easterly face. The north-west side affords the main evidence on which the structure of the hill is based, but it too is obscured except in a few places where slips disclose the solid beds underneath. The following is the sequence of the beds, as far as can be judged, commencing from the bottom:—

1. *Yellowish sands*, of uncertain thickness, but probably very thick; they extend downwards till they are covered with surface debris and the gravels of the plains. The upper 12 inches contains inclusions of greensand, and these get more and more numerous as the junction with the overlying bed is approached. In the lower part of the layer they are very scarce.
2. *Greensand*, dark green in colour, 2 ft.; at the base there is a layer of phosphatic nodules, very numerous, up to 2 inches in diameter, and associated with many sharks' teeth.
3. *Clayey Beds*, at the base definitely sandy and glauconitic, but at the top more argillaceous, but still sandy and glauconitic, 6ft.
4. *Ash-bed*, well stratified, with coarser and finer layers, occasionally showing basic glass, 12 ft. This bed is about 300 ft. above the level of the plain, and can be traced round the hill-slopes for several hundred yards.
5. *Sands*, with irregular layers of fragmentary shells, 2 ft.

For some distance above this bed, about 100 ft., the sequence is obscured, but it is probably sandy. Then the sequence is resumed with—

6. *White quartz sands*.
7. *Ash-bed*, weathering red, 6 ft.
8. *Fragmentary volcanic layer*, up to 2 ft. thick, probably passing up into No. 9.
9. *Basaltic lava flow*, 50 ft., scoriaceous in places, and in places containing inclusions of porcellanite.

There are exposures of these beds in a few places on the sides of two gullies to the north, but they are of very limited extent. Ash-beds resting on clayey beds passing down into greensand and passing up into fragmentary shell-beds occur for certain, and, as far

as can be judged, with a dip to the east at the northern end of the hill, as if there was an apparent conformation to the quavquaversal dip characteristic of a volcanic cone, and suggesting that the centre lay to the west of the hill, between it and View Hill. Sands, yellowish in colour, appear in places, and a bore put down for water near the homestead at the northern end of the ridge passed through 260 ft. of them. I think that these must represent the lowest sands mentioned in the table, that is, No. 1 of the series. I did not see samples, but Mr. Bassett, the owner of the station, has informed me of the fact.

At the south-western end of the ridge the top beds exposed consist of lava-flows with intervening ash-beds, dipping south-east at an angle of about  $10^{\circ}$ . At least three flows are probably present in this section. They are very scoriaceous in places, and the lowest contains near the base a quantity of porcellanite. Under the solid flow there is a layer of large angular fragments, then a reddish ash, while the lowest beds exposed are white quartz sands.

All round the base of the hill are the gravels of the Canterbury Plains, completely masking the beds lying below.

The occurrence at Burnt Hill is very interesting, since Tertiary fossils are found in beds interstratified with volcanic material. The layer where they occur is unfortunately somewhat narrow, being from 3 to 12 inches in thickness, and the shells are very badly preserved and difficult to obtain in good condition. The layer was excavated in several places, and it is possible that if the excavations were made deeper better results might be obtained. Then again other points where fossils occur may chance to give a better harvest when they are located. Collections were made on two occasions and the whole of them submitted to Dr. J. Marwick, of the N.Z. Geological Survey, and he has kindly furnished a report on them, the substance of which is as follows:—

*b. List of Fossils.*—The list of Burnt Hill fossils to date is now quite a respectable one with 42 species; but its exact correlation is still rather uncertain. From the assemblage of genera he would say that the age was certainly Miocene, for they are practically all common Awamoan ones; but there is a lack of characteristic Awamoan species and a surprising number are new. From the presence of *Struthiolaria praeunantia*, *Alcithoe* cf. *arabacula*, *Melatoma* aff. *wanganuiensis* and *Baryspira* cf. *subhebera* he would be inclined to place the age as slightly younger than the typical Awamoan.

The following is the list as furnished:—

<i>Acteon</i> n. sp.	<i>Baryspira</i> cf. <i>subhebera</i> (Marw.).
<i>Alcithoe</i> cf. <i>arabacula</i> Marw.	<i>Corbula canaliculata</i> Hutton.
<i>Austrofuscus</i> cf. <i>spinifera</i> (Fin.)	<i>Corbula</i> cf. <i>kaiparaensis</i> Marsh.
<i>Austrofuscus</i> ( <i>Neocola</i> ) n. sp.	<i>Crepidula wilckensi</i> Fin.
<i>Austrofuscus</i> ( <i>Nassicola</i> ) cf. <i>nassa</i>	<i>Crepidula</i> sp. probably new.
Fin.	<i>Cryptomella</i> n. sp.
<i>Austrosipho</i> n. sp. aff. <i>adusta</i> (Philippi).	<i>Dentalium solidum</i> Hutton.
<i>Austrotoma</i> n. sp.	<i>Diplodonta</i> ( <i>Zempsia</i> ) n. sp.
<i>Baryspira robusta</i> (Marw.).	<i>Dosinia</i> ( <i>Kereia</i> ) n. sp.
	<i>Eucrassatella attenuata</i> (Hutt.).

<i>Eulimella</i> n. sp.	<i>Paradione</i> ( <i>Notocallista</i> ) n. sp.
<i>Eumarcia</i> ( <i>Atamarcia</i> ) n. sp. aff.	<i>Polinices lobatus</i> (Marw.).
<i>curta</i> (Hutt.).	<i>Polinices mucronatus</i> (Marw.)
<i>Gari lineolata</i> (Gray).	<i>Spinomelon</i> sp.
<i>Gari</i> n. sp. aff. <i>stangeri</i> (Gray).	<i>Struthiolaria</i> aff. <i>spinosa</i> Hector.
<i>Glycymeris</i> n. sp. aff. <i>laticostata</i>	<i>Struthiolaria prænuntia</i> Marw.
(Q. and G.).	<i>Syrnola</i> n. sp.
<i>Glycymeris</i> n. sp. aff. <i>shrimptoni</i>	<i>Thracia</i> cf. <i>magna</i> Marsh. and
Marw.	Murdoch.
<i>Linatula</i> cf. <i>maoria</i> Fin.	<i>Turbo operculum</i> .
<i>Marama</i> ( <i>Hina</i> ) cf. <i>mackenziei</i>	<i>Turritella</i> n. sp.
Marw.	<i>Turbonilla</i> n. sp.
<i>Melatoma</i> n. sp. aff. <i>wanganuiensis</i>	<i>Typhis</i> cf. <i>maccoyi</i> T.-Woods.
(Hutt.)	<i>Venericardia</i> n. sp. aff. <i>purpurata</i>
<i>Mesalia</i> n. sp.	(Desh.).
<i>Mydora</i> n. sp.	<i>Venericardia</i> aff. <i>zelandica</i> (Desh.)
<i>Panope worthingtoni</i> Hutt.	<i>Verconella</i> n. sp.

## C. PETROLOGY.

## 1. Chemical Analyses.

The chemical composition of rocks representative of the area is given by the analyses in the accompanying table. For these I have to express my indebtedness to Mr. P. G. Morgan, Director of the Geological Survey, who arranged to have the rocks analyzed in the Dominion Laboratory; I have also to express my thanks to Dr. MacLaurin and to Mr. Seelye for the great care taken in making these analyses.

	1	1a	2	3	4	5	6	7
Silica ... .. $\text{SiO}_2$	50.91	53.42	52.02	50.28	52.83	52.23	65.77	70.90
Alumina ... .. $\text{Al}_2\text{O}_3$	14.28	14.98	13.61	13.36	13.70	14.27	15.03	14.33
Ferric Oxide ... .. $\text{Fe}_2\text{O}_3$	2.95	3.10	1.98	3.73	4.58	4.27	2.27	0.23
Ferrous Oxide... .. $\text{FeO}$	6.46	6.78	8.50	5.94	6.95	7.27	2.23	2.55
Magnesia ... .. $\text{MgO}$	5.27	5.53	5.99	6.59	8.10	6.67	1.87	1.11
Lime ... .. $\text{CaO}$	10.08	7.82	9.21	8.78	8.30	8.31	3.34	1.31
Soda ... .. $\text{Na}_2\text{O}$	2.81	2.95	2.62	2.65	2.40	2.62	3.31	3.56
Potash ... .. $\text{K}_2\text{O}$	0.53	0.56	0.59	0.72	0.47	0.42	2.25	2.73
Water lost above 105 $\text{H}_2\text{O} +$	0.60	0.63	1.24	1.53	0.63	0.75	2.25	1.75
Water lost below 105 $\text{H}_2\text{O} -$	1.93	2.02	1.70	3.88	1.23	0.89	0.29	0.36
Carbon di-Oxide ... $\text{CO}_2$	2.07	—	0.39	0.06	0.02	trace	0.03	0.20
Titanium di-Oxide ... $\text{TiO}_2$	1.67	1.75	1.76	2.05	1.02	1.55	0.70	0.50
Phosphorus pentoxide $\text{P}_2\text{O}_5$	0.20	0.21	0.28	0.35	0.18	0.24	0.23	0.12
Zirconium di-Oxide ... $\text{ZrO}_2$	—	—	—	—	—	—	—	0.03
Sulphur ... .. $\text{S}$	0.08	0.08	0.04	0.04	trace	trace	0.01	0.05
Chronic Oxide... .. $\text{Cr}_2\text{O}_3$	0.04	0.04	0.04	0.05	0.06	0.05	none	none
Nickel Oxide ... .. $\text{NiO}$	0.03	0.03	0.04	0.03	0.03	0.05	trace?	trace
Mangeneous Oxide ... $\text{MnO}$	0.14	0.15	0.15	0.12	0.22	0.14	0.07	0.06
Strontia ... .. $\text{SrO}$	0.02	0.02	0.02	0.03	0.02	0.03	0.04	0.02
Baryta... .. $\text{BaO}$	trace?	—	0.02	0.02	0.02	0.02	0.08	0.06
	100.07	100.07	100.20	100.21	99.79	99.68	99.77	99.87

Norms.	1	1a	2	3	4	5
Q	8.70	8.64	6.66	6.72	6.90	8.04
or.	2.78	3.34	3.34	3.89	2.78	2.22
ab	23.58	25.15	22.01	22.53	20.44	22.01
an.	25.02	25.85	23.63	22.52	25.02	26.13
di	8.99	9.67	14.35	14.39	12.30	11.44
hy.	15.71	16.38	19.18	14.14	22.83	18.44
mt.	4.41	4.41	3.02	5.34	5.34	6.26
il.	3.19	3.34	3.34	3.95	1.98	3.19
ap.	0.34	0.34	0.67	1.01	0.34	0.34
cc.	(4.70)	—	(0.90)	(0.10)	—	—

Analyst, F. T. Seelye.

- No. 1. Dolerite, View Hill, S.W. end.—(11)(111). 4(5). (3)4. (4)5. Bandose.  
 No. 1a Dolerite, View Hill, S.W. end. No. 1 re-calculated on the basis of the absence of calcite from the sample.—(11)(111). 4(5). (3)4. (4)5. Bandose.  
 No. 2. Basalt, "Pillow-Lava," Whites Creek.—"111. (4)5. (3)4. 4(5). Auvergnose.  
 No. 3. Dolerite, Eyre River, just over the Chalk.—"111. (4)5. 3(4). 4". Camptonose.  
 No. 4. Hypersthene Dolerite, Junction of Whites Creek and Eyre River.—"111. 4(5). "4. (4)5. Koghose.  
 No. 5. Hypersthene Dolerite, Burnt Hill, Oxford, S. side middle saddle.—(11) 111. 4(5). "4. "5. Koghose.  
 No. 6. Greywacke, Gorge Hill, Waimakariri, on rise N. side of the Bridge.  
 No. 7. Greywacke, Otira Tunnel, Arthurs Pass.

The analyst notes with regard to No. 7 that a very small amount of carbonaceous matter was detected in the sample, and that owing to its presence the percentage given for  $\text{FeO}$  may possibly be higher; and that for  $\text{Fe}_2\text{O}_3$  slightly lower, than the true figures.

These analyses show that the rocks of the area have a somewhat striking uniformity in chemical composition and also that they fit in with somewhat rare types of basic rocks in the C.I.P.W. system, viz., koghose and bandose. A specially noticeable feature is the occurrence of weighable quantities of nickel, chromium, and strontium.

I will deal with the microscopical features of the rocks of each of the areas in turn.

## 2. *Microscopical Description of Rocks.*

a. *View Hill.*—The rock analyzed came from the S.W. end of the ridge. It is dark grey in colour, rough to the feel and vesicular. Under the microscope it appears to be composed of felspar (basic-labradorite) in broad laths up to 2mm. in length; the majority about half that length; augite, grey in colour, occasionally purplish; olivine in large grains up to 0.75mm. in length, altered along cracks to yellowish secondary products; ilmenite in irregular, occasional skeletal forms; also chlorite giving a greenish stain to portions of the rock. As far as could be seen from the hand specimen, this sample of the rock was fresh and unaltered, but other facies show considerable variation from this; notably is this the case when the rocks are coarser and more decomposed.

One of these coarser varieties exhibits the following characters. The feldspars and augites average about 2mm. in length, the former typically a medium-labradorite, the latter greyish-green with a more pronounced greenish border; there is some olivine; calcite filling cavities either in grains or forming aggregations of radiating fibres; very occasional epidote; titaniferous magnetite or ilmenite, brownish black in colour and partly altered to leucoxene; occasional apatite; and flecks of mica frequently associated with magnetite and forming a border to it. The structure is at times most beautifully ophitic. The feldspars exhibit some peculiarities. The usual type is labradorite, but it is often bordered by an untwinned feldspar with lower index than balsam; there are as well grains of orthoclase apparently unconnected with original labradorite. Zeolites are also present in fair amount. One of these is fibrous, with higher polarization colours than quartz, straight extinction and low index of refraction, which corresponds to natrolite. This has been derived from the feldspar, since grains of feldspar can be seen passing into it or partly replaced by it. There is also another derived mineral in sheaves of radiating fibres, with low polarization colours, and refractive index about that of balsam; this probably corresponds to phillipsite. Both of these zeolites are associated with grains and needles of aegerine-augite, the needles often arranged in radiating groups like the stellate forms of schorl. These occurrences show a decidedly alkaline relationship, and the decomposed facies of the rock is thus easily accounted for. In some slides there is a little of the zeolitic material and its associated minerals. Also, the augite is occasionally diallagite. This feature is strongly reminiscent of the coarser types of the dolerite at the Acheron River, especially the more gabbroid portions, which are also noteworthy since they contain fairly numerous inclusions of natrolite. I saw no nepheline or other feldspathoid in the View Hill rocks to account for the presence of the zeolites, and therefore conclude that they have been derived from the feldspar originally present.

The indurated sandstones occurring under these rocks are composed of quartz grains of an average diameter of 0.2 to 0.3mm. with extensive outgrowths of mossy quartz which no doubt acts as a cementing agent.

b. *Eyre River*.—Three rocks from this area were analysed. The first of these to consider is the pillow-lava from Whites Creek. In the hand specimen this is a dark-coloured rock, smooth and compact in appearance, with small steam-vesicles of which some are filled with amygdaloids. In some cases the vesicles are large and elongated. The analysis shows that the rock is a somewhat acid basalt, with no suggestion of the albitization characteristic of some of the pillow-lavas. Under the microscope the rock appears to be finely even-grained and non porphyritic. There is much feldspar (labradorite) in stumpy laths 0.1 to 0.25mm. in length, frequently with forked ends. Augite occurs freely in grains and laths; olivine in very small grains; and patches of glass obscured with dust of magnetite and needles of ilmenite. Calcite occurs in quantity, either as isolated patches and aggregations or as amygdaloids. There are also amygdaloids of chaledony up to 1.5mm. in diameter, stained greenish-yellow with alteration products.

Some specimens are coarser in texture and show augite as grains packed between felspar laths or at times intergrown sub-ophitically. The augites are up to 1mm. in length and the felspars 0.75mm. The former in places occur in aggregations of crystals. The felspar is labradorite.

A fair number of specimens from about this horizon were examined microscopically and all proved to be basic in character. Some contain abundant olivine, as for example the dolerite exposed in the bed of the Eyre, near the old farm-house.

A most interesting occurrence of a basalt of limburgite facies was noted in the slides obtained from chips of an outcrop about three-quarters of a mile east of the pillow-lava quarry. Under the microscope the rock appears to be even grained in texture, with a few phenocrysts of augite and of olivine, the latter represented in places by alteration products. I saw no phenocrysts of felspar in the slides, but a re-examination of the locality disclosed the fact that felspar phenocrysts, some up to 2cm. in length, do occur. It is possible that the exact spot where the specimens were obtained was not located. The groundmass appears to be composed of much augite, a base of glass about the same index of refraction as balsam, and patches of an isotropic substance with refractive index definitely lower than balsam, with a rough surface, which may be analcite. There were also very occasional laths with low polarization colours and straight extinction, which looked like nepheline but did not show its usual habit. They might after all be felspar, and if so this was the only occurrence of felspar in the slide. The description thus answers to that of a limburgite. This is one of the oldest occurrences of igneous rocks in the locality, since it lies almost down on the greywacke, with but a very small thickness of sands intervening.

At the eastern end of this area there are several occurrences of very fine-grained compact basalt. Under the microscope the only phenocrysts appear to be olivine, which occurs freely in grains up to 0.8mm. in length. The groundmass is composed of felspar laths about 0.1mm. in length. Small grains of augite, skeletal forms of magnetite, amygdaloids of calcite, and colourless isotropic mineral of higher index of refraction than balsam, occur in the spaces between the felspar laths, the last being no doubt a glass. These rocks are comparable as regards their basicity with the limburgitic facies of the basalt further west, which like them lies down near the base of the series just above the greywacke substratum on which these Tertiary beds lie.

A rock occurring at an intermediate horizon is that on the shelf north-west of Chalk Hill. This is a basalt with holocrystalline groundmass composed of augite grains and felspar laths. The phenocrysts are augite, often in aggregations of grains up to 1mm. in length, and abundant olivine in clear and colourless crystals, 1mm. in length, occasionally altered to greenish-yellow secondary products; there are micro-phenocrysts of plagioclase, ilmenite in many needle-shaped and skeletal forms, and occasional calcite. This rock is intermediate in texture between the pillow-lavas and the dolerites which are found higher in the series.

The second analysis from the Eyre River area, the third in the table, is that of the rock which immediately overlies the chalk in the bed of the river. This is a dolerite of fairly even grain. The felspar, a basic labradorite, forms crystals up to 1.25mm. in length with an average of about 0.5mm. The augite is faint purplish in colour, slightly pleochroic, and often in nests of crystals. Olivine occurs sparingly. Ilmenite forms broken-comb shapes and skeletal crystals, and also occurs as a fine dust clouding patches of glass. Chalcedony occurs in amygdules composed of radiating fibres stained green with alteration products.

Analysis No. 4 is of a specimen from the junction of Whites Creek and the Eyre River, and represents what is practically the most recent flow belonging to this area. The rock is grey in the hand specimen, rough to the feel, and somewhat vesicular, the vesicles being lined inside with yellowish alteration products. The texture of this rock is somewhat fine for a typical dolerite. The phenocrysts are of hypersthene, up to 1.5mm. in length, slightly pleochroic, usually in long quadrangular forms with longitudinal and cross-cleavages well developed, slightly pleochroic, and bordered and also intergrown with augite, often occurring in nests of crystals; augite also occurs, as well as occasional olivine stained with iron oxide. The groundmass is composed of felspar (labradorite); augite generally in equidimensional forms about 0.25mm. in length; and magnetite or ilmenite in grains and skeletal laths. The rock is thus a fine grained hypersthene dolerite.

On the western and southern slopes of Chalk Hill dolerites similar in features to this rock occur freely. They contain little olivine but considerable amounts of hypersthene, as is generally the case with the latest flows throughout the district.

Micro-sections were made of some of the siliceous masses i.e., "chinamen," associated with these basic rocks. They proved to be formed almost wholly of quartz grains of two sizes. The larger are subangular, occasionally well rounded, and with a diameter ranging from 2 to 4mm., and averaging 3mm., while packed in between them are numerous smaller grains averaging from one-fifth to one-tenth the diameter of the larger grains. These in a few places appear to be definitely attached to the larger grains as outgrowths, but are generally quite separate from them. Occasional grains of zircon also occur.

*c. Starvation Hill.*—Four samples were selected from this locality, all coming from the big gully that has cut back into the hill on the south-eastern face. The specimens were selected so as to give some idea of the variation between the earlier flows and the latest. All the specimens taken were basalts or dolerites.

The first to be considered comes from the lowest beds exposed near the mouth of the gully. This is a dark-grey rock, usually compact, but with steam-holes sporadically distributed through it; phenocrysts of felspar, augite, and olivine are plainly visible in the hand-specimen. Under the microscope the phenocrysts appear to be of labradorite up to 2.5mm. in length and of augite up to 1mm., the latter frequently surrounded with a border of granular augite; and very occasional grains of olivine. The groundmass is holocrystalline and composed of laths of felspar, grains of augite and skeletal forms

of magnetite, the average length of the feldspars of the base being 0.25mm.

The next specimen is a moderately close-grained, non-vesicular, dark-coloured rock in the hand specimen. Under the microscope it is a fine grained dolerite or coarse basalt, composed of feldspar laths up to 0.5mm. in length; augite in grains and short stumpy laths up to 0.5mm. in length; olivine in grains; quadrangular and skeletal forms of titaniferous magnetite; and phenocrysts of hypersthene in long quadrangular forms up to 1.5mm. in length, definitely pleochroic, and bordered with monoclinic augite.

Above this is found a grey, vesicular rock, which also proves to be a hypersthene-basalt. The hypersthene is in short stumpy forms as well as in long quadrangular laths, up to 1.5mm. in length, definitely pleochroic, and bordered with augite.

Olivine occurs in reddish-brown forms (iddingsite). I noticed no augite phenocrysts. The base consists of feldspar laths, augite grains, and black iron ores.

The specimen from the topmost flow is very similar to this last but slightly more vesicular. The hypersthene occurs in forms characteristic of the area, the olivine is unaltered, but there are large grains of magnetite up to 2mm. in diameter in addition to the smaller quadrangular and skeletal forms.

As in other parts of the district the later appearances of volcanic rocks are characterized by the presence of hypersthene, and this may serve to indicate that they are all of about the same age.

d. *Burnt Hill*.—The specimen analyzed came from the southern side of the saddle which divides the Burnt Hill ridge into two almost equal parts. Microscopically the rock is dark-grey in colour, somewhat vesicular, and rough to the feel. It has in the field in some cases a distinctly reddish or pinkish tint which is probably due to the oxidation of the olivine it contains. Microscopically it is an even-grained rock, composed of feldspar (labradorite) laths with an average length of 0.5mm.; a rhombic pyroxene with faint pleochroism, straight extinction, and negative character, therefore no doubt hypersthene; augite in smaller amount frequently twinned and also as a border to and intergrown with hypersthene; olivine stained brown with oxide of iron and forming iddingsite; much brownish-black titaniferous magnetite in grains of primary origin, as well as secondary ilmenite in broken-comb forms, both stained with whitish leucoxene; also apatite in stumpy needles. This rock may therefore be called a hypersthene-augite dolerite.

Other rocks from this locality show a similar composition, hypersthene occurring in all that were sectioned. Iddingsite is fairly common, but in some cases the larger olivines, really phenocrysts, show no alteration in that direction and are virtually fresh, whereas the micro-phenocrysts of olivine are stained with iron oxide. In some cases the augite is slightly purplish in colour. The texture varies, some specimens being sufficiently coarse for dolerites, while others are typical basalts.

The ash-bed under the fossil layer was also examined microscopically and showed the following composition. The field was composed mainly of a mosaic of calcite, fragments of volcanic glass, some dark in colour and other yellowish in tint (palagonite) containing bubbles

filled in some cases with calcite and in others with chalcedony as well as numerous grains of magnetite. There were in addition fragments of augite, some blue-green in colour, hypersthene, olivine, felspar, flakes of mica, needles of apatite, and fairly numerous grains of glauconite. Most of these materials are similar to those occurring in the subsequent flows, but, as far as I know, the greenish augite does not occur as a constituent of these.

e. *Occurrences in the Waimakariri.* — As recorded previously volcanic rocks outcrop in three places close to the bed of the Waimakariri within the district under consideration. These are at Browns Rock, Rock Ford, and Woodstock.

(1) *Browns Rock.*

This rock is a rather fine-grained dolerite, somewhat vesicular in texture. It is porphyritic with phenocrysts of hypersthene up to 2mm. in length in rectangular forms about three times as long as broad, and with outgrowths of augite; olivine also occurs occasionally in grains which are usually clear and colourless and up to 1mm. in diameter. The groundmass is holocrystalline with the elements of sub-equal size, and consisting of felspar (labradorite), averaging about 0.25mm. in length; augite, in stumpy laths and grains sometimes optically intergrown with the felspar; grains of fresh and clear olivine; and grains and skeletal forms of brownish-black iron ore, altering to leucoxene and margined with hematite therefore in all probability, ilmenite. The last-named does not occur in such large amount as in the other rocks of the area.

(2) *Rockford.*

The occurrence here is a dolerite, somewhat coarse grained in texture, and composed of augite and felspar (labradorite) in subophitic relationship; occasional hypersthene with a border of augite and very slightly pleochroic up to 2mm. in length; olivine in occasional grains; titaniferous-magnetite; and needles of apatite. The presence of hypersthene suggests a connection with the more recent flows in other parts of the district and with the occurrence at Browns Rock, but the texture belongs to an intrusive rather than to an effusive rock.

(3) *Woodstock.*

This in the hand specimen is a fine-grained rock, dark in colour, vesicular in places but generally compact with small amygdaloids plainly showing here and there. Under the microscope it shows an even-grained texture, the constituent minerals being felspar laths and augite, in places optically intergrown, the former are labradorite and have an average length of about 0.1mm. There are numerous small amygdaloids of chalcedony, and occasional larger ones up to 1mm. in diameter, all stained slightly green, but with the polarization colours and index of refraction and occasional fibrous structure of that mineral. There is also much ilmenite of secondary origin, in characteristic forms, sometimes forming aggregations round the amygdaloids. This is the most acidic rock encountered in the area.

f. *Greywackes.*—The last two analyses are those of two typical samples of greywacke, one from near the Waimakariri Gorge Railway Bridge and the other from Arthurs Pass. There are five inliers of greywacke in the area under consideration, and it was considered

an advantage if representative samples could be submitted for analysis, especially as so few analyses of greywacke are available, in spite of the rock being the most important in the fabric of New Zealand as a whole.

The greywacke inliers are situated as follows: (1) near the junction of the Eyre and Whites Creek, (2) the north-western part of View Hill, (3) Eagle Hill and its extensions towards the Waimakariri, (4) Rockford, where there are at least two exposures, one forming the rock in the river near the old crossing, and the other forming a projecting mass on one of the lower terraces of the river, (5) at the Lower Gorge, where it forms for some distance the high banks on both sides of the river. In the last-named locality the greywacke is associated with well-bedded slaty shales, striking N.N.W. and dipping at high angles—much crushed in places with irregular dip and affected by small faults. Alongside this is a typical greywacke, forming a small hill to the north of the bridge. Analysis No. 6 is of a piece taken from here. In the hand specimen this shows the coarse grey facies of greywacke, very hard and tough. Under the microscope it appears to be composed mainly of quartz, and there are notable quantities of the feldspars, both orthoclase and plagioclase, as well as subordinate amounts of both micas, augite, epidote, titanite, zircon, and calcite.

The most striking feature of the analysis is the relatively high value of the fraction  $\frac{\text{Na}_2\text{O}}{\text{K}_2\text{O}}$ —a feature of the No. 7 analysis as well—

which may be taken to indicate that the greywackes were the debris of a granite land, but not subjected to much decomposition. If this had taken place to any extent then the fraction should have been smaller since soda-bearing minerals, especially feldspars, are in general more susceptible to decomposing agents than those bearing potash. All the same the composition of the parent rock must exert some influence on the ratio, for a rock in which there is a relative excess of soda to start with, will produce with a small amount of decomposition a rock in which the fraction is greater than unity, while one with a small amount of soda will have a low fraction in any case, no matter whether the resulting detrital matter has been produced by decomposition or disintegration as the dominant destructive process.

In this case the low quantity of combined water supports the inference deduced from the high soda to potash ratio that disintegration and not decomposition was the dominant factor in producing the materials of greywacke from the parent rock.

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## The Tertiary Mollusca of the Chatham Islands including a Generic Revision of the New Zealand Pectinidae.

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### NOTE BY H. J. FINLAY, D.Sc.

Owing to unforeseen delay in publication of my account of the Chatham Island Recent Mollusca and the usage by Dr. Marwick in the following paper of some of the new names there given, it is necessary in order to avoid priority confusion to make the following formal propositions:

*Ellicea* n. gen. for *Siphonalia orbita* Hutton.

*Notostrea* n. gen. for *Ostrea subdentata* Hutton.

*Notostrea lubra* n. sp. for *Gryphaea tarda* Tate, not Hutton.

*Scalpomactra* n. gen. for *Mactra scalpellum* Reeve.

### 1. INTRODUCTION.

THE first list of specifically identified fossils from the Chatham Islands was that published by Hutton in his Catalogue of Tertiary Mollusca 1873. Thirteen species were recognised, all except "*Gryphaea*" *tarda* represented in New Zealand, and three occurring in the recent fauna. No exact locality had been supplied with the specimens, and as the assemblage did not closely correspond to that of any New Zealand horizon, Hutton thought that more than one formation had been collected from. He says (1873, p. viii.): "The fossils from the Chatham Islands appear to be mixed, as shells characteristic of the Kanieri group, the Ahuriri formation, and the Trelissick group are all in the collection. I think it probable that two formations occur there, one belonging to the Pareora formation, and the other intermediate between the Ahuriri and Oamaru forma-

tions. If, however, there should be only one formation present, I should be inclined to refer it to the Ahuriri period."

Many of Hutton's specimens have been lost and the exact locality of their origin was never stated, but all except "*Gryphaea*" *tarda* probably came from Pitt Island, and formed part of Geological Survey locality collection 792 (H. H. Travers).

A critical examination of the fossils available shows that nearly all of Hutton's records of species common to Chatham Islands and New Zealand are based on wrong identifications.

Many years later, Hutton (1902) described a single fossil, *Pecten dendyi*, given him by Professor A. Dendy, of Christchurch, and probably collected at Momoe-a-toa where the species is abundant.

During the 1924 expedition, the chief collections of Mollusca were made at four main spots on Chatham Island, and Mr. R. S. Allan was able to make another at Flower-pot Harbour, Pitt Island. In the following year he obtained additional material from these places, and also discovered a new and richly fossiliferous locality on Whenuataru Peninsula, Pitt Island.

## 2. DESCRIPTION OF FOSSILIFEROUS LOCALITIES.

### (1.) Momoe-a-toa.

The most northerly point of Chatham Island is Cape Young, one mile to the south-west of which projects Momoe-a-toa. The fossils occur in a tuffaceous limestone between two lava-flows, on the northern side and well out towards the point.

### (2.) Tioriori.

The fossiliferous locality is about four miles south along the coast from Momoe-a-toa, and about half a mile north-east of Tioriori and Tutuniri Creek. The fossiliferous bed is a soft bryozoan limestone with occasional quartz pebbles, and is exposed in the sea cliffs which are about 50 feet high. The limestone rests disconformably on green unfossiliferous tuffs.

### (3.) Titirangi.

Titirangi is a bluff about 75 feet high, half way along the southern shore of the north-western extension of Te Whanga Lagoon known as Muriwhenua. The bluff can be seen from afar, for it is crowned by a karaka grove. The fossils are found on the northern or lake side.

### (4.) Waikaripi.

The Wireless Station stands on high country about one mile south-west of Waitangi, and in the sea cliffs south-west, below the Wireless Station, are two bands of fossiliferous, tuffaceous limestone separated by unfossiliferous, calcareous tuffs.

### (5.) Flower-pot Harbour, Pitt Island.

This locality is on the northern bay of Pitt Island. The fossiliferous tuffs occur at Onoua, on the eastern side of the harbour, and unconformably overlie a bryozoan limestone.

### (6.) Whenuataru Peninsula, Pitt Island.

Whenuataru Peninsula forms the north-west corner of Pitt Island, and is about one mile west of the Flower-pot. The richly

fossiliferous tuffs outcrop on the south side of the Peninsula, and, as at the Flower-pot, unconformably overlies a bryozoan limestone.

The fossils at all of these localities except No. 3, Titirangi, are associated with a relatively extensive group of limestones and tuffs which Mr. Allan has named the Wharekauri-Waitangi Series. These rocks cover a considerable part of the islands and are of mid-Tertiary age. At Titirangi the fossiliferous beds are unconsolidated shell sands of restricted occurrence and obviously belong to the late Tertiary.

### 3. FAUNA OF THE WHAREKAURI-WAITANGI SERIES.

#### a. General Discussion.

Perhaps the most striking feature of the fossils from the limestones and tuffs is the individuality shown by the faunules of each of the localities except the Pitt Island ones. The species collected from more than one locality are tabulated below.

	Momoe-a-toa	Tioriori	Waitangi	Waikaripi	Flower-pot	Whenuataru
<i>Glycymeris traversi</i>	..	..	..	..	x	x
<i>Glycymeris hunti</i>	..	..	..	..	x	x
<i>Placopecten hectori</i>	..	..	..	..	x	..
<i>Chlamys chathamensis</i>	x	..	..	..	x	..
<i>Chlamys seymouri</i>	x	..	..	..	x	..
<i>Limatula morioria</i>	x	..	..	..	x	x
<i>Limnaea chathamensis</i>	x	..	..	..	..	x
<i>Notostrea tarda</i>	..	x	..	x	..	..
<i>Cardita northcrofti</i>	..	..	..	..	x	x
<i>Venericardia beata</i>	..	..	..	..	x	x
<i>Chama pittensis</i>	..	..	..	..	x	x
<i>Tawera marshalli</i>	..	..	..	..	x	x
<i>Nemocardium diversum</i>	..	..	..	x	..	?
<i>Corbula howesi</i>	..	..	..	..	x	x
<i>Turritella solomoni</i>	..	..	..	..	x	x
<i>Cochlis pittensis</i>	..	..	..	..	x	x
<i>Austrosipho asper</i>	..	..	..	..	x	x
<i>Waihoia renwicki</i>	..	..	..	..	x	x
<i>Phenatoma decessor</i>	..	..	..	..	x	x

At Momoe-a-toa the fossils consist almost wholly of large Pectens and Brachiopods, though there are a few casts of *Glycymeris*, *Panope*, *Nuculana*, etc. At Tioriori, *Notostrea tarda* is abundant with an oyster, occasional Pectens, a *Cirsotrema* and Brachiopods, but with the exception of the *Notostrea* the species are all peculiar to this place. At Waikaripi, at the Flower-pot and at Whenuataru Peninsula there are mixed faunas; but the large Pectens of Momoe-a-toa are absent, and the Waikaripi faunule is very different from the Pitt Island ones which have a strong resemblance to each other in their commonest shells.

The fossiliferous beds can be divided into two groups,—

A. Upper (Calcareous Tuffs)	{	Momoe-a-toa
		Flower-pot
		Whenuataru
B. Lower (Bryozoan Limestone)	{	Tioriori
		Waitangi
		Waikaripi
		Flower-pot

The absence of identical or related species at most of the localities is perhaps due more to difference of station than to difference of age. However the matrix of the Flower-pot fossils resembles that of the Waikaripi ones and both places have the genera *Nemocardium*, *Venericardia*, *Corbula*, and *Chlamys* so that the environment was probably similar. The lack of specific agreement therefore is a fair indication of difference in age. Further, a number of the Mollusca from Whenuataru and the Flower-pot have strong Wanganui affinities, e.g., *Thyasira flexuosa*, *Venericardia beata*, *Cardita northcrofti*, *Corbula howesi*, *Merelina avita*, *Phenatoma decessor*. It is therefore possible that a considerable time-interval separates the calcareous tuffs from the bryozoan limestone; but for the present it seems best to consider all as belonging to one period.

Seventy-nine species of Mollusca have been recognised from the marine tuffs and limestones; and of these only two (2.5%) are Recent. Both identifications of the Recent species are founded on poor material, so it is likely that they too can be separated as new when more specimens are collected.

Much has been written about the Lyellian method of reckoning position in the Tertiary sequence by means of the percentage of contained Recent Mollusca; but the work done on this subject by modern American palaeontologists has not received sufficient attention in New Zealand. Using only those localities with 50 species or over Dall (1903, p. 1617) got for the Eastern American Oligocene from 2 to 12% Recent, and for the Miocene 13 to 20%. (The upper part of Dall's Oligocene is now classed in the Miocene).

Martin and Glen's work on the Miocene of Maryland (Clark, Shattuck and Dall, 1904, p. cxlix) gave only 10% of Recent Mollusca.

The San Pablo group of Middle California supplied 23.5% Recent forms to Bruce Clark (1915, p. 424) who placed the beds as Upper Miocene or possible Lower Pliocene.

In a recent paper on the comparative value of various organisms in zoning, Vaughan (1923, p. 519) says, "The percentage of Recent Mollusks in the Lower Miocene ranges between 3 and 7.5 per cent."; he also gives a table showing eleven Miocene localities with percentages ranging from 3 (Lower Miocene) to 27 (Upper Miocene), and two Oligocene localities where there are no Recent species.

The very low percentage of Recent forms in the Chatham Island fauna (2%, perhaps 0%) shows that it belongs to early or middle Tertiary times, and the generic assemblage favours classifications as Upper Oligocene or Lower Miocene.

Of the eighty species only four occur in New Zealand. They are: *Thyasira flexuosa*, *Taurea marshalli*, *Rissoina chathamensis*, and *Cochlis notocenica*. None of these species is represented by well-preserved specimens, so that the identifications are not above suspicion. Most of the genera have been common in New Zealand since the Waiarekan, and some of the species have close relatives in our middle and later Tertiary strata.

The occurrence of the genus *Perotrochus* one of the Pleurotomariidae is interesting. A fine new species was found by Mr. Allan in the cliffs at Waikaripi, below the Wireless Station. Though always exceedingly rare in the Tertiary, the family has remarkably wide distribution, and there are four Recent species. *P. tertiaria* McCoy has been found at only one locality in Australia in Lower Tertiary Beds, and the specimens from the Wharekuri greensand, Waitaki Valley, were classed by Hutton (on rather poor grounds) under the same species. The exact age of these Wharekuri beds remains to be demonstrated, but it is probably Ototaran or Hutchinsonian; that is, somewhere about the Oligocene.

A large *Perotrochus*, perhaps the same species as that at Wharekuri, is fairly common in the Hutchinsonian greensands at Allday Bay, Kakanui; but the specimens are difficult to collect. The Chatham Island shell, though belonging to the same imperforate genus, *Perotrochus*, is quite distinct specifically, so that no correlation can be made by means of it.

Another noteworthy shell is "*Gryphaea*" *tarda* Hutton. Specimens from the Balcumbian and Janjukian of Southern Australia were identified by Tate (1886, p. 98) as the same species; and Ortmann (1902, p. 113) compared with *G. tarda*, a shell supposed to be from the Patagonian beds. Recently, Finlay has shown that the Australian shells are specifically distinct from the Chatham Island ones and has named them *Notostrea lubra*. Ihering (1907, pp. 6, 245) cast a certain amount of doubt on the Tertiary occurrence of Ortmann's specimen and identified it as the Upper Cretaceous *G. burckhardtii* Boehm.

The writer agrees with Finlay (in ms.) that *G. tarda* is related to the genus *Notostrea* Finlay, and thinks it probable that the Australian and South American species have arisen independently from *Ostrea*. Trueman (1922, p. 264) has already shown such to have happened with Jurassic "*Gryphaea*."

#### b. Faunal Lists of Wharekauri-Waitangi Series.

(Recent species marked \*)

- |  |   |
|--|---|
| (1) Momoe-a-toa, Chatham Island.                 | <i>Limea chathamensis</i> n. sp.                  |
| <i>Glycymeris hunti</i> n. sp.                   | <i>Ostrea arcuata</i> n. sp.                      |
| <i>Monia furcilla</i> n. sp.                     | <i>Cirsotrema chathamense</i> n. sp.              |
| <i>Sectipecten allani</i> n. sp.                 | <i>Cirsotrema parvulum</i> n. sp.                 |
| <i>Sectipecten toaensis</i> n. sp.               | (2) Tioriori, Chatham Island.                     |
| <i>Chlamys chathamensis</i> (Hutton)             | <i>Serripecten tiorioriensis</i> n. sp.           |
| <i>Chlamys seymouri</i> n. sp.                   | <i>Lentipecten imperfectus</i> n. sp.             |
| <i>Pallium</i> (? <i>Felipes</i> ) <i>dendyi</i> | <i>Ostrea cannoni</i> n. sp.                      |
| (Hutton)   | <i>Notostrea tarda</i> (Hutton)                   |
| <i>Limatula morioria</i> n. sp.                  | <i>Cirsotrema</i> ( <i>Tioria</i> ) <i>youngi</i> |
|  | n. sp.  |

- (3.) Waikaripi, near Wireless Station, Chatham Island.  
*Mytilus (Aulacomya) willetsi* n. sp.  
*Chlamys mercuria* n. sp.  
*Ostrea waitangiensis* n. sp.  
*Notostrea tarda* (Hutton)  
*Venericardia nuntia* n. sp.  
*Ascitellina donaciformis* n. sp.  
*Nemocardium diversum* n. sp.  
*Corbula tophina* n. sp.  
*Perotrochus allani* n. sp.  
*Margarella runcinata* n. sp.
- (4.) Calcareous tuffs, Flower-pot, Pitt Island.  
*Arca pittensis* n. sp.  
*Barbatia (Pugilarca) barneiformis* n. sp.  
*Lissarca fossilis* n. sp.  
*Glycymeris traversi* (Hutton)  
*Glycymeris hunti* n. sp.  
*Placopecten hectori* (Hutton)  
*Chlamys chathamensis* (Hutton)  
*Chlamys seymouri* n. sp.  
*Lima vasis* n. sp.  
*Limatula morioria* n. sp.  
*Ctenoides naufragus* n. sp.  
*Cardita northcrofti* n. sp.  
*Venericardia beata* n. sp.  
*Chama pittensis* n. sp.  
*Tawera marshalli* Marwick  
*Corbula howesi* n. sp.  
*Emarginula galeriformis* n. sp.  
*Tugalia aranea* n. sp.  
*Maurea finlayi* n. sp.  
*Imperator anthropophagus* n. sp.  
*Argalista effusa* n. sp.  
*Argalista arta* n. sp.  
*Merelina avita* n. sp.  
*Notosinister insertus* n. sp.  
*Turritella (Spirocolpus) solo-  
moni* n. sp.  
*Cochlis pittensis* n. sp.  
*Trivia flora* n. sp.  
*Austrosipho (Verconella)  
asper* n. sp.  
*Waihaeia (Pachymelon) ren-  
wicki* n. sp.  
*Marginella floralis* n. sp.  
*Zemacies prendrevillei* n. sp.  
*Guraleus lineatus* n. sp.
- (5.) Bryozoan limestone, Flower-pot, Pitt Island.  
*Cirsotrema propelyratum* n. sp.
- (6.) Whenuatara Peninsula, Pitt Island.  
*Glycymeris traversi* (Hutton).  
*Glycymeris hunti* n. sp.  
*Limopsis invalida* n. sp.  
*Limatula morioria* n. sp.  
*Limea chathamensis* n. sp.  
*Cuna antiqua* n. sp.  
*Cardita northcrofti* n. sp.  
*Venericardia beata* n. sp.  
*Chama pittensis* n. sp.  
*\*Thyasira flexuosa* (Mont.).  
*Leptomya concentrica* n. sp.  
*Dosinia (Kereia) chathamensis* n. sp.  
*Tawera marshalli* Marwick.  
*Nemocardium diversum* n. sp.  
*Corbula howesi* n. sp.  
*Emarginula galeriformis* n. sp.  
*Zeminolia levis* n. sp.  
*\*Rissoina chathamensis* n. sp.  
*Turritella (Spirocolpus) solo-  
moni* n. sp.  
*Cochlis pittensis* n. sp.  
*Cochlis notocenica* (Finlay)  
*Cochlis* n. sp., cf. *australis* (Hutton).  
*Globisium mucronatum* n. sp.  
*Korovina accelerans* n. sp.  
*Phalium (Kahua) skinneri* n. sp.  
*Odostomia pittensis* n. sp.  
*Austromitra plicifera* n. sp.  
*Austrosipho (Verconella)  
asper* n. sp.  
*Ellicca (Pittella) firma* n. sp.  
*Cominella (Eucominia)  
bauckei* n. sp.  
*Zeatrophon lussus* n. sp.  
*Waihaeia (Pachymelon) ren-  
wicki* n. sp.  
*Baryspira* n. sp.  
*Marginella coxi* n. sp.  
*Inquisitor acutus* n. sp.  
*Mitrithara granum* n. sp.  
*Phenatoma decessor* n. sp.  
*Retusa pressa* n. sp.

## 4. FAUNA OF THE TITIRANGI SERIES.

a. *General Discussion.*

The lower twelve feet or so of Titirangi Bluff is formed of fairly soft Bryozoan limestone, on the eroded surface of which lie the Titirangi beds. No angular unconformity can be observed between the limestone and the shell beds; both are practically horizontal.

The fossils are in a beautiful state of preservation, and can be obtained in countless numbers, the one drawback being that the variety of species is comparatively small. Thirty-eight species were obtained of which twenty-six are Pelecypods and twelve Gasteropods. This predominance of Pelecypods, their large size and strength, and the great numbers of *Amphidesma*, indicate that the containing beds were laid down in quite shallow water bordering an open beach of shell sand.

Sixteen of the thirty-eight are Recent species, that is 42%. This suggests correlation with the Waitotaran or lower stage of the Wanganui system, although the most characteristic species of that stage are not represented. The large heavy *Eumarcia* which is common in the basal four feet of the shell-bed at the western end of the outcrop appears to be conspecific with *E. plana* Marwick from the Waitotaran and the lower part of the Nukumaruan beds. Also *Paphirus largillierii* (Philippi), *Gari stangeri* (Gray), *Zemysia zelandica* (Gray), and *Glycymeris modesta* (Angas) are present in great numbers, and *Dosinia wanganuiensis* Marwick is not uncommon. The writer therefore favours correlation with the Nukumaruan, i.e., the middle stage of the Wanganui. The European equivalent of the Titirangi beds is thus about Middle Pliocene.

Specimens of a large barnacle from the Titirangi beds were submitted to Mr. T. H. Withers of the British Museum. He identified them as *Balanus* (*Megabalanus*) *tubulatus* Withers (1924, p. 28, pl. 7, figs. 1-10). This species was originally described from the Lower Pliocene of Castle Point and Waipara Gorge, New Zealand.

b. *List of Fauna from Titirangi.*

(Recent species marked \*)

<i>Barbatia</i> ( <i>Acar</i> ) <i>whangaensis</i> n. sp.	<i>Neogaimardia elegantula</i> n. sp.
* <i>Glycymeris laticostata</i> (Q. and G.)	<i>Cuna firma</i> n. sp.
<i>Glycymeris waipipiensis</i> Mar- wick .	<i>Venericardia martini</i> n. sp., common.
* <i>Glycymeris modesta</i> (Angas), common.	<i>Condylocardia torquata</i> n. sp.
<i>Philobrya galerita</i> n. sp.	* <i>Zemysia zelandica</i> (Gray), common.
<i>Perrierina ovata</i> n. sp., com- mon.	* <i>Myllitella pinguis</i> n. sp., com- mon.
* <i>Mytilus</i> ( <i>Aulacomya</i> ) <i>maoria-</i> <i>nus</i> Iredale.	<i>Amphidesma</i> ( <i>Taria</i> ) <i>porrec-</i> <i>tum</i> n. sp., common.
<i>Chlamys titirangiensis</i> n. sp.	* <i>Mactra rudis</i> Hutton.
* <i>Limatula maoria</i> Finlay.	* <i>Scalpomactra scalpellum</i> (Reeve).
	<i>Dosinia</i> ( <i>Phacosoma</i> ) <i>wanga-</i> <i>nuiensis</i> Marwick.

- |   |  |
|---|--|
| * <i>Paradione</i> ( <i>Notocallista</i> ) <i>multistriata</i> Sowerby. | <i>Rangimata pervia</i> n. sp.   |
| <i>Bussinaria macchurgi</i> n. sp.                                      | * <i>Zethalia zelandica</i> (Adams).                                   |
| <i>Tawera marthae</i> n. sp., common.                                   | <i>Estea insulana</i> n. sp.   |
| <i>Eumarcia plana</i> Marwick, common.                                  | <i>Estea subtilicosta</i> n. sp.                                       |
| * <i>Paphirus largillierti</i> (Philippi), common.                      | <i>Ataxocerithium simplex</i> n. sp.                                   |
| * <i>Gari stangeri</i> (Gray), common.                                  | * <i>Zegalerus crater</i> Finlay, common.                              |
| * <i>Barnea similis</i> (Gray).   | <i>Cominella</i> ( <i>Eucominia</i> ) <i>elli-soni</i> n. sp., common. |
| <i>Atalacmea elata</i> n. sp.   | <i>Zeatrophon mutabilis</i> n. sp., common.                            |
| * <i>Microelenchus rufozona</i> (Adams), common.                        | * <i>Zemitrella choava</i> (Reeve).                                    |
|   | <i>Liracrea titirangiensis</i> n. sp.                                  |

## 5. EXTERNAL RELATIONS.

The great bulk of the Molluscan fauna of the Chatham Islands, both Recent and fossil, is generically the same as that of New Zealand. The specific relationship of the Recent and Pliocene faunas of the two areas, however, is closer than that of the mid-Tertiary ones. This may be due to our not yet having discovered in New Zealand strata exactly corresponding in time and conditions of deposition to the fossiliferous tuffs of the Chathams. Most of the Oligocene and Miocene fossiliferous localities of New Zealand also, however, have marked individuality in their faunules, so that it is not common to find extensive specific identity at any two places. Of course further collecting will bring forth more material common to different localities; but apart from the time factor this lack of specific identity may have resulted from the presence in this region at that time, of groups of islands sufficiently isolated to develop well-differentiated faunal provinces.

At the present time, marine currents carry drift from New Zealand to the Chathams; but we do not know what Molluscan species can or can not avail themselves of this transportation. Therefore, while the great bulk of the genera have been derived from New Zealand, we cannot yet tell from the Molluscan evidence whether the Chatham Islands have ever been actually joined to the mainland of New Zealand.

## 6. ACKNOWLEDGMENTS.

In conclusion, I should like to express my sincere thanks to the residents of the Chatham Islands, not only for their kindness and hospitality to the party as a whole, but also for their invaluable help in selecting an itinerary and in locating places and formations of palaeontological importance. I am specially indebted to Dr. E. Ellison, at that time Resident Magistrate, and Mrs. Ellison, to Mr. Robert McClurg and Mrs. R. Hough of Te Roto, and to Mr. Charles Seymour of Wharekauri; also to Mr. and Mrs. C. Cannon of Maunganui, Mr. N. R. Cox of Aotea, Mr. and Mrs. J. Prendreville, and Mr. and Mrs. J. Renwick of Ouenga.

I must also thank the officers of the Otago Institute who organized the Expedition for their kindness in including me in a most profitable and enjoyable excursion, and, in addition, Mr. P. G. Morgan, Director of the New Zealand Geological Survey, and Mr. A. K. Kimbell, Under-Secretary for Mines for permitting me to take part in it.

Much of the success of the expedition was due to the enthusiasm of its leader, Mr. H. D. Skinner, antropologist, whose cheerful and ready help was ever at our disposal. Dr. H. J. Finlay has given valuable aid in discussing and criticising the systematic classifications and nomenclature to be adopted.

Finally I would acknowledge my deep indebtedness to my field companion, Mr. R. S. Allan, geologist. In addition to his stratigraphic, petrologic, and physiographic work, he excelled as a fossil-hunter, for the bulk of the specimens described below were collected by him.

#### 7. SYSTEMATIC CLASSIFICATION AND DESCRIPTIONS.

Note: All of the types, except that of *Pallium dendyi* are in the collection of the New Zealand Geological Survey.

##### a. CLASS *PELECYPODA*.

Genus *ARCA* Linné, 1758.

Type: *Arca noae* L.

##### ***Arca pittensis* n. sp.** (Figs. 5, 6.)

Shell of moderate size, thin, rhomboidal, inflated, beaks at anterior sixth, distant; posterior area flattened, bounded below by strong ridge running from umbo to bottom of short and obliquely-truncated posterior margin. Sculpture of disc mostly worn away, but as far as can be seen consisting of spaced radial threads, arranged in pairs with wide interstices, the whole crossed by strong growth-lines; posterior area has crowded, wavy, radial threads, 3 to 4 per millimeter, rendered irregularly moniliform by growth-lines. Hinge long and narrow with a central smooth area not coinciding with angle of ligamental chevrons; behind this smooth space are 13 oblique teeth, in front from 12 to 14; the posterior 5 of the latter inclined upwards and backwards. Ligamental area very broad with about 14 well-marked ligamental chevrons; ventral margin of valves irregularly, weakly dentate.

Height 15 mm.; length 30 mm.; thickness (1 valve) 10 mm.

Locality: Flower-pot Harbour, Pitt Island.

Remarks: This species is related to *Arca subvelata* Suter from Target Gully, but has a shorter posterior margin and so a different shape, also the ligamental grooves are more crowded.

Genus *BARBATIA* Gray, 1847.

Type: *Arca barbata* Linné.

##### a. Subgenus *Acar* Gray, 1887.

Type: *Arca gradata* Brod. and Sowb.

##### ***Barbatia (Acar) whangaensis* n. sp.** (Figs. 1, 4.)

Shell small, subrhomboidal, beaks about anterior fourth, curved strongly forward; anterior end horizontal for short distance above,

then regularly rounded, posterior broader than anterior, horizontal above, then very obliquely truncated, ventral margin with broad shallow sinus; rounded ridge bounding posterior area runs from umbo to postero-ventral corner. Sculpture of about 12 primary ribs which by anastomosing produce about 24 at adult margin; these are crossed by very strong regular concentric growth-ridges raised on radials into strong scales. Teeth 6 to 8 anterior and 10 to 12 posterior, not separated by smooth space. Area very narrow, not well defined anteriorly, one strong groove bounding the area running from beak to end of hinge-line, but seldom any others and then they are quite short. Valve-margin crenulated.

Height 4 mm.; length 7 mm.; thickness (1 valve) 2 mm.

Locality: Titirangi.

Apparently closely related to *Arca sociella* Brookes from North Auckland and to *Arca botanica* Hedley from southern and eastern Australia, but with fewer ribs than either of these.

b. Subgenus *Pugilarca* nov.

Type: *Barbatia barneaformis* Marwick.

Differs from *Barbatia* and *Acar* in having a wide space devoid of teeth on the central part of the hinge. The teeth have not been obliterated by a descending area, but have never developed. The beaks are nearer the anterior end than in either of these genera and the area like that of *Acar* is very narrow, having only one straight groove, which is behind the beak. The sculpture though fundamentally the same presents a very different appearance because the radial and concentric elements are about equally developed, the ribs are coarse and the interspaces are wide. The valve-margins are smooth as far as can be seen, not crenulated like those of *Acar*.

***Barbatia (Pugilarca) barneaformis* n. sp. (Figs. 2, 3.)**

Shell rather small, subrhomboid, fragile, beaks at anterior fifth; anterior end narrowly convex, posterior end with straight dorsal margin and slightly convex, obliquely truncated posterior margin, ventral margin broadly convex, ascending in front; a prominent rounded ridge runs from umbo to blunt posterior ventral angle. Sculpture: middle and anterior of disc with about 20 primary radials with secondaries appearing later and equalling the primaries, all bearing strong tubercles, surface of disc has regular concentric growth-ridges about 0.6 mm. in width, posterior area has 7 weak radials of same structure as the others. Hinge narrow, four anterior teeth separated by wide space from 12 oblique posterior teeth. Area linear, a single ligamental groove extending backwards from umbo along top of teeth a little over half way to postero-dorsal angle. Valve margins smooth, sharp.

Height 11.5 mm.; length 21 mm.; thickness 5 mm.

Locality: Flower-pot Harbour, Pitt Island.

## Genus LISSARCA Smith, 1877.

Type: *L. rubrofusca* Smith.*Lissarca fossilis* n. sp. (Figs. 24, 25.)

Shell very small, oval, inflated, beaks small, close to anterior end. Surface apparently smooth except for a few strong spaced growth-lines. Hinge-plate arched, narrow, with four chevroned posterior taxodont teeth and about five nearly straight anterior ones, the two sets separated by a relatively large obliquely-triangular ligament-pit. Valve-margins with about three denticles, posteriorly anteriorly, and ventrally.

Height 3.2 mm.; length 3.7 mm.; thickness (1 valve) 1.5 mm.

Locality: Flower-pot Harbour, Pitt Island.

Resembles *L. exilis* Suter, but is larger, has no trace of radial sculpture and very few marginal crenulations.

## Genus GLYCYMERIS da Costa, 1778.

Type: *Arca glycymeris* Linné.*Glycymeris traversi* (Hutton).

1873. *Pectunculus traversi* Hutton, *Cat. Tert. Moll.* p. 28.

1914. *Glycymeris traversi* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull.* 2, p. 35, pl. 4, figs. 2a, b.

1923. *Glycymeris traversi* (Hutton): Marwick, *Trans. N.Z. Inst.*, vol. 54, p. 66, pl. 1, fig. 8.

Localities: Flower-pot Harbour, Pitt Island; Whenuataru Peninsula, Pitt Island.

*Glycymeris laticostata* (Quoy and Gaimard).

1835. *Pectunculus laticostatus* Q. and G., *Voy. Astrol.* vol. 3, p. 466, pl. 77, figs. 4-6.

1913. *Glycymeris laticostata* Q. and G.: Suter, *Man. N.Z. Moll.*, p. 851, pl. 56, figs. 3, 3a.

Locality: Titirangi, a single damaged specimen.

*Glycymeris huntii* n. sp. (Figs. 7, 10.)

Shell of moderate size, light, obliquely oval, beaks narrow, somewhat low. Sculpture consisting of fine regular radial threads, 5 per mm., superposed on a system of very low primary ribs which cannot be distinguished distally and so are of uncertain number; sometimes these ribs are slightly convex, but sometimes they are quite flat. Hinge-area somewhat narrow, teeth narrow, curved, about 15 anterior and 12 posterior without a median space; ligamental area narrow, with 6 striae about 0.5 mm. apart from each other. Valve-margin with about 50 fine crenulations the distal ones very small.

Height 35 mm.; length 40 mm.; thickness (1 valve) 10 mm.

Localities: Flower-pot Harbour, Pitt Island; Whenuataru Peninsula, Pitt Island; (?) Momoe-a-toa (cast).

This species closely resembles *G. shrimpstoni* Marwick, but this is probably a convergence for the obliquity is present from a very early stage, the young being like *G. modesta*. In *G. shrimpstoni* only some adults show obliquity, the young and many full grown ones being practically symmetrical.

**Glycymeris waipipiensis** Marwick.

1923. *Glycymeris waipipienis* Marwick, *Trans. N.Z. Inst.*, vol. 54, p. 75, pl. 5, fig. 5, pl. 6, fig. 5.

Locality: Titirangi.

Only imperfect specimens were found.

**Glycymeris modesta** (Angas).

1879. *Axinaea modesta* Angas. *P.Z.S.*, p. 418, pl. 35, fig. 4.

1913. *Glycymeris modesta* Angas: Suter, *Man. N.Z. Moll.*, p. 852, pl. 51, figs. 8, 8a.

Locality: Titirangi, common.

Genus *LIMOPSIS* Sassi, 1827.

Type: *Arca aurita*, Brocchi.

**Limopsis invalida** n. sp. (Figs. 11, 12.)

Shell small, obliquely oval, moderately inflated, beaks low. Sculpture of concentric grooves separating wide flat interspaces, weak radials developed only on small portion of anterior and posterior areas. Hinge with about 5 short anterior and 5 posterior teeth, also 3 or 4 imperfect ones in the middle. Ligamental area narrow, central pit rather small. Valve-margins smooth.

Height 7 mm., length 7 mm., inflation (1 valve) 2.2 mm.

Locality: Whenuataru Peninsula, Pitt Island.

*L. invalida* closely resembles *L. waihaeensis* Allan, but can be distinguished by its different ornamentation and slightly wider ligament pit.

Genus *PHILOBRYA* Carpenter, 1872.

Type: *Bryophila setosa* Cpr.

**Philobrya galerita** n. sp. (Figs. 22, 27.)

Shell minute, obliquely ovate, thin, beaks near anterior end, with raised disc-shaped prodissoconch; anterior end narrowly rounded, dorsal and ventral margins diverging towards semicircular posterior margin. Surface showing close sharp concentric ridges, and three or four marked growth-periods, also four low spaced radial ridges on posterior end. Hinge narrow, with broadly-triangular ligamental fossette, in front of which are about 10 narrow taxodont teeth and behind about 16 arranged in two tiers with third tier faintly indicated. Valve-margins sharp, bevelled, with six strong posterior crenulations; ventral margin with two or three very weak ones, the anterior margin smooth.

Height 1.2 mm.; length 1.5 mm.; thickness (1 valve) .5 mm.

Locality: Titirangi.

Only a single right valve was found. It somewhat resembles *Hochstetteria trapezina* Bernard, concerning the generic position of which Finlay (1926, p. 449) has shown there is considerable doubt.

Genus *PERRIERINA* Bernard, 1897.

Type: *P. taxodonta* Bernard.

*Perrierina ovata* n. sp. (Figs. 8, 9.)

Shell minute, ovate, equivalve, inequilateral. Beaks fairly prominent, with a well defined, rounded, projecting prodissoconch. Sculpture of crowded microscopic concentric threads. Hinge narrow, with central triangular or trapezoidal ligament-pit separating about 4 or 5 anterior and 4 or 5 posterior teeth, all horizontal and straight except a rounded or tubercular one on each side of the central pit. Valve-margins sometimes with a few indistinct crenations on the ventral margin, sometimes quite smooth.

Height 1.5 mm., length 1.7 mm., inflation .5 mm.

Locality: Titirangi, common.

Suter has put this genus in the Crassatellitidae; but conchologically, *Perrierina* has no resemblance to this family. The writer does not know of any other shell with a hinge like *Perrierina* and so proposes the new family *PERRIERINIDAE*.

Genus *MONIA* Gray, 1849.

Type: *Anomia macroschisma* Deshayes.

*Monia furcilla* n. sp. (Fig. 20.)

Shell small, of irregular shape according to habitat, left valve with fine, rounded, waved radial ribs sometimes anastomosing, with equal interstices, 2 to 3 per mm., crossed by close regular scaly concentric lamellae, about 5 per mm., the whole surface irregularly puckered. The muscle-scars could not be seen, so the generic position is uncertain. The shell may be an *Anomia*, but from the resemblance of its sculpture it is more likely congeneric with *Monia furcata* (Hutton) from which it differs in having more regular, much finer radial sculpture.

Height 19 mm.; length 18 mm.

Locality: Momoe-a-toa.

Genus *MYTILUS* Linné, 1758.

Type: *M. edulis* L.

Subgenus *Aulacomya* Moersch, 1853.

Type: *Mytilus magellanicus* Lam.

*Mytilus (Aulacomya) maorianus* Iredale.

1915. *Mytilus maorinus* Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 4, 484.

Locality: Titirangi.

A few damaged specimens, some with ribbing much coarser than is usual in the Recent shells.

*Mytilus (Aulacomya) willetsi* n. sp. (Fig. 15.)

Shell very small for the group, attenuated, well inflated; beaks terminal; dorsal margin short and straight; posterior margin parallel to the anterior one, both relatively long. Sculpture of numerous waved, radial riblets many of which branch, giving a divaricate appearance. The ribs are strongest down the raised middle of the

dise and are about 2 per mm. at the ventral margin, on the anterior margin they gradually become finer until they are from 3 to 4 per mm. The hinge is not clearly exposed but there is a ligamental groove along the dorsal margin.

Height 10 mm.; length 10 mm.; inflation (1 valve) 3 mm. (holotype). A paratype is 13 x 13 x 3.5 mm.

Locality: Waikaripi below Wireless Station, Waitangi.

### Family PECTINIDAE.

Before the Pectens of the Chathams could be satisfactorily classified, a rough revision of the generic and subgeneric grouping of New Zealand species had to be undertaken. The results of this survey are here presented. Suter's classification was as follows (Recent species marked\*) :—

#### 1. Genus Pecten Muller.

##### A. Subgenus *Pecten*.

##### (1) Section *Pecten* s. str.

*athleta* Zittel.

##### (2) Section *Euvola* Dall.

\**medius* Lamarek (not the West Indian species but \**novae-zelandiae* Reeve, see Iredale 1924, p. 193).

##### B. Subgenus *Chlamys* Bolten.

##### (1) Section *Chlamys* s. str.

\**dichrous* Suter, \**imparvicostatus* Bavay, \**radiatus* Hutton, \**zelandiae* Gray, \**zelandiae gemmulatus* Reeve, *aldingensis* Tate (not of Tate but *uttleyi* Marwick, 1924, p. 325), *chathamensis* Hutton, *semiplicatus* Hutton, *williamsoni* Zittel, *hilli* Hutton, *dendyi* Hutton.

##### (2) Section *Pallium* Schumacher.

\**convexus* Quoy and Gaimard, *burnetti* Zittel.

##### (3) Section *Patinopecten* Dall.

*accrementus* Hutton, *beckhami* Hutton, *crawfordi* Hutton, *delicatulus* Hutton (with which was synonymized *diffusa* Hutton, wrongly so, see Thomson, 1919, p. 282) *hutchinsoni* Hutton, *marshalli* Suter, *sectus* Hutton, *triphooki* Zittel, *venosus* Hutton.

##### (4) Section *Aequipecten* Fischer.

*devinctus* Suter.

##### C. Subgenus *Pseudamussium* H. and A. Adams.

##### (1) Section *Pseudamussium* s. str.

*hochstetteri* Zittel, *waihaoensis* Suter, *yahlensis* Ten.-Woods (not of T.-Woods but *hectori* Hutton, see Marwick, 1924, p. 326).

##### (2) Section *Cyclopecten* Verrill.

\**aviculoides* Smith, \**transenna* Suter.

##### D. Subgenus *Camptonectes* Meek.

*huttoni* Park.

#### 2. Genus AMUSIUM Bolten.

*papakureense* Clarke, *zitteli* Hutton.

## 3. Genus HINNITES DeFrance.

*trailli* Hutton.

The oldest *Pecten* known from New Zealand is that described by Trechmann (1918, p. 206) as *Pecten* sp. from the Upper Trias of Nugget Point. The figure looks much like that of a *Chlamys*, but insufficient material exists to show clearly.

From the Jurassic, Trechmann (1923, p. 276) described two species, *Pecten* (*Camptonectes*) cf. *lens* Sowerby and *Pecten* (*Syncyclonema*) sp. Some additional material goes to confirm the first identification; but Trechmann's second shell is not like a *Syncyclonema*. The apical angle is much greater, the ears are subequal and there is no trace of sculpture. It would be better classed as a *Pseudamussium*.

The Clarentian (Albian) beds of Marlborough have not furnished material good enough for specific determination. Woods (1917, p. 8) recorded *Pecten* (*Camptonectes*) sp., and *Pecten* (*Syncyclonema*) sp. The first has the fine divaricate striae of *Camptonectes* but I have not seen the supposed *Syncyclonema*.

Woods (1917, pp. 25, 26) also described three species from the Upper Senonian of Amuri Bluff and Selwyn Rapids.

1. *Pecten* (*Syncyclonema*) *membranaceus* Nilsson.

*Syncyclonema* seems to be rather loosely used by many palaeontologists for all smooth Cretaceous *Pecten*s. The genotype, *S. rigida* Hall and Meek, is a small shell with discrepant sculpture, the right valve having weak radials and the left spaced concentric ridges. Also the ears are noticeably unequal, horizontal along the top in both valves, and meet the disc in a regular curve. The byssal sinus is apparent in both valves. The New Zealand shells have equal, high, unsinused ears, and both valves have fine regular concentric ridges; therefore they do not belong to *Syncyclonema*. No specimens or figures of the typical *P. membranaceus* are available in New Zealand, so a safe criticism of the specific placing of our shells cannot be made. Stoliczka's figures of supposed *P. membranaceus* from the Ariyalur, stated by Woods to be "closely allied to or identical with this species," show shells with ears quite different from the New Zealand ones. If they are *P. membranaceus*, our shells are certainly not. It is likely that a new specific name also a new generic one are needed for these Amuri shells, but for the present they are classed as *Pseudamussium*, *sensu lato*.

2. *Pecten* (*Camptonectes*) *hectori* Woods.

The specific name was preoccupied by Hutton, 1873, consequently Morgan (in Wilkens, 1922, p. 32, footnote) substituted *P. woodsi*. This change was overlooked by Finlay (1927, p. 526) who proposed *Camptonectes selwynensis* for the species. I am indebted to Dr. Finlay for the reference to a prior *Pecten woodsi* Woldrich, 1918, *Jahrb. Geol. Reichsanst. Wien*; as a result *Camptonectes selwynensis* must be used.

3. *Pecten* (*Aequiptecten*) *amuriensis* Woods.

This shell differs widely from the type of *Aequiptecten*, *P. opercularis* L., which is a large though thin shell with subequal, inflated

valves, uniform, strong, not dichotomous radials, and subequal ears with a moderately deep notch. *P. amuriensis* is much smaller in size and has unequal valves, the right flattened and practically smooth, the left inflated and strongly sculptured; also the unequal ears are joined to the shell without a separating canal, and the posterior edge meets the disc on a curve. The byssal notch is very deep. These features make the creation of a new genus necessary, so *Mixtipecten* is proposed with *Pecten amuriensis* Woods as type. Perhaps *Cyclopecten* is related to this Cretaceous stock.

The early Tertiary beds of New Zealand are not rich in *Pectens*, but in the Otoraran they are much commoner and larger. In Hutchesonian, Awamoan, and younger beds the family is represented by many different specific groups sometimes containing very large individuals. One of the earliest is *P. devinctus*, which has subequal valves traversed by high, broad, radial ribs, the interspaces with waved radial threads. Supposed descendants are *diffusus*, *wollastoni* (= *sectus*), and *allani*. These shells have still subequal valves though the left may be slightly less inflated; the sculpture consists of strong, high radials which tend to anastomose with age; and the rib-interspaces have fine, regular, concentric ridges. The ears are fairly large, right-angled, subequal; byssal sinus definite but not deep. *P. crawfordi* which appeared in Lower Pliocene times may be a development from *P. diffusus* by increased splitting of the radials. The ears are similar but the left valve is much flatter than the right, and the folding of the disc is stronger. Suter's use of *Patinopecten* for these shells is not to be recommended. *P. caurinus* Gould, the genotype, has large flat valves, the ears set on them without a separating channel; also the byssal notch is wide and deep. None of the major divisions of the Pectinidae agrees well with these New Zealand shells so the new genus *Sectipecten* is proposed with *Pecten wollastoni* Finlay (= *P. sectus* Hutton) as type.

The Mid-Tertiary *P. athleta* Zittel may be an offshoot from the main *Sectipecten* line of descent. The valves are equally inflated; but the radial ribs are rounded and the concentric ridges are irregular both in strength and disposition. The byssal notch is very deep and the right valve has narrow, paired, primary radials, whereas the left has broad, equally-spaced ones. These differences warrant the creation of the new subgenus *Athlopecten* with *Pecten athleta* Zittel as type. Suter's classification of this species under *Pecten* s. str. is offset by his placing under *Patinopecten* of *P. marshalli* which is very closely related to *S. athleta*. In *Athlopecten* the valves are equally inflated the left has broad ribs and the right, narrow, paired ones, in *Pecten* the right valve is much inflated and has broad ribs, the left is flat and has narrow ribs.

The ancestry of the Pliocene *P. triphooki* is not known. In this large shell the right valve is quite flat and the left is strongly convex. The sculpture consists of regular, radiating, fairly strong ribs, the interspaces with fine, even, concentric ridges. The ears are very large and subequal, the byssal notch being well marked, and the hinge-crura almost absent. The flattening of the right valve and the deep sinus may indicate relationship to *Chlamys*; but the absence of scales and the presence of fine regular concentric ridges as well as

the large posterior ears show that the relationship is not close. When the valves of a *Pecten* are unequally inflated, the most inflated valve has generally broader ribs than the flatter valve. Therefore the presence of broad ribs in the left valve of *S. athleta* perhaps means connection with *P. triphooki*. In any case relationship either to *Chlamys* or to *Sectipecten* is distant, so the new genus *Phialopecten* is proposed with *Pecten triphooki* as type. *P. hilli* and *P. accrementus* were, like *P. triphooki*, described from fragmentary material from the Napier limestone and are doubtfully separable from this species. Further collecting is needed to show the value of these divisions. Certainly a great number of forms are grouped round *P. triphooki* and several specific divisions are required.

The type of *Euvola*, *P. ziczac* L., has quite obsolete radial ribs in the right valve, with only linear interspaces, whereas *P. novaezelandiae* has strong ribs with wide interspaces. An ancestor of *novaezelandiae* from the Upper Pliocene of Castlecliff has very low rounded radials, but the interspaces are wide, and the shells are closer to *Pecten* s. str. Finlay (1926, p. 451) has recently proposed *P. novaezelandiae* as type of a new division, *Notovola*, because of the weak hinge-erura, flat or concave left valve "and the right valve also has none of the secondary ridges characteristic of *Pecten maximus* L., the type of *Pecten*, the ribs are higher and flatter, and the interstices deeper, smooth and narrower." *P. laqueatus* Sowerby (Pliocene and Recent of Japan) agrees in all respects with *P. novaezelandiae* except that it has twelve instead of sixteen ribs. Also *P. bellus* Conrad (Pliocene of California) and *P. larteti* Tournouer (Helvetian of Aquitaine) may belong to the group. *Notovola* is quite as distinct from *Pecten* s. str. as is *Euvola* and is therefore used here as a subgenus of *Pecten*.

The typical *Chlamys* is well represented in New Zealand, especially from about the Oligocene onward, indeed the shell figured by Trechmann (1918, pl. 21, fig. 18) from the Trias of Nugget Point, might belong to this division. From Suter's list the following species should be transferred to other groups: *uttleyi* (*aidingensis* of Suter) to *Serripecten* (*Janupecten*); *semiplicatus* and *dendyi* to *Pallium* (? *Felipes*); *hilli* to *Phialopecten*. The Ototaran *P. venosus*, which has not yet been figured, is a *Chlamys* so its classification under *Patinopecten* was wide of the mark. Suter did not see a specimen when he revised Hutton's types, but one of the types, a right valve, has since come to light. The shell is small, about 1½ inches in diameter, and has from 10 to 12 smooth, rounded radials. The interspaces, about as wide as the ribs, but flat, are also smooth for the first inch. On the last half inch they contain about four scaly threads. A left valve collected from tuffs in the Ototara limestone by Professor Park in 1916 is much flatter than the right valve, and the scaly threads are present on the ribs as well as in the interspaces. The ears are subequal and acute, with fine scaly threads. This shell probably represents an offshoot from *Chlamys* which proceeded but a short way from the main stock, for we do not know of any descendants in later deposits.

The specimens on which the Californian *P. andersoni* Arnold was identified in New Zealand (Morgan 1911, p. 72) are casts; but they

are not that species, for the ribs divide at about an inch from the apex. As far as can be seen they belong to a new species and perhaps a new group, not closely related to any known New Zealand shell.

The type of *P. scandula* has not yet turned up, and no topotypes have been encountered, so that nothing definite can be said about this species. From Hutton's description, however, it seems fairly sure that he was dealing with a *Chlamys* s. str.

*Pallium* in a wide sense represents one of the major divisions of the Pectinidae, its members being widely distributed. The typical species *P. plica* Lamarek, from the Chinese seas, has strong hinge-erura, so that the New Zealand shells do not fit well into *Pallium* s. str. The subdivisions of the genus are extremely confused and badly need monographing. Dall (1898, p. 696) mentions *Felipes* Locard, *Peplum* Buequoy, Dautzenberg, and Dollfuss, and *Flexopecten* Sacco. *Nodipecten* Dall and *Lyropecten* Conrad given by Dall as independent sections are also related. Cossmann (1914, p. 312) under the genus *Chlamys* recognised the subgenus *Manupecten* Montr. 1889 (= *Felipes* Carus 1889) containing the section *Flexopecten* Sacco, but did not mention *Felipes* Locard. It is possible that one or all of the New Zealand species belong to an already separated division, perhaps to *Felipes*, so for the present *Pallium*, *sensu lato*, is recommended.

*Pecten beethami* and *P. hutchinsoni* belong to a group that lived in New Zealand seas during the early and middle Tertiary. The sculpture is not like that of any other division of the family, for the inflated right valve has over thirty peculiarly-bevelled, scaly, primary radials, whereas the left valve is crowded with from 60 to 80 fine, scaly, radial threads. The earliest known example is a left valve from the Waihao greensand at McCulloughs Bridge (Upper Eocene); somewhat later comes "*Chlamys*" *enfieldensis* Marwick from the Waiarekan. By Hutchinsonian times the shells had increased greatly in size, *P. beethami* being often over 6 ins. in diameter. Awamoan examples are much the same as the Hutchinsonian ones, but about this time the whole group apparently died out. *P. yahlensis* Tenison-Woods, from the Janjukian of Victoria, is an Australian representative agreeing closely with the typical *P. hutchinsoni* except in having weaker sculpture. The group has perhaps descended from an early *Chlamys*, but it is not closely connected with any known genus of the Pectinidae so the new genus *Serripecten* is proposed with *P. hutchinsoni* Hutton as type.

*Serripecten* seems to have an innate tendency towards obsolescence of the sculpture. Thus McCoy (1876, p. 13) described a species *P. yahlensis* var. *semi-laevis* with a smooth right valve. In New Zealand are a number of species showing smoothing of the left valve, or of both valves, but none in which the right has proceeded further along this road than the left. *P. uttleyi* Marwick (1924, p. 325) is a good example of this loss of sculpture. Considerable variation is met with in this shell, but some right valves show clearly the resemblance to *Serripecten*. *P. hochstetteri* Zittel as interpreted by Park and Suter (but not by Hutton) also belongs to this group, as was noticed by Tate. Other specimens from several localities of Otoraran

and Huthinsonian age show this smoothing of the left valve, and supply clear links with *Serripecten*. It is certain that the tendency extended over a long period, and so all shells with weak sculpture in the left valve are not necessarily directly related. In *P. uttleyi*, however, the obsolescence of sculpture has gone so far that the general appearance of the shell is quite different; consequently the new subgenus *Janupecten* with *P. uttleyi* as type is proposed. The ribbed shell included in Zittel's *P. hochstetteri*, and named below *S. polemicus*, can also be classed as *Janupecten*.

When Zittel (1864, p. 50) described *P. hochstetteri*, he had material belonging to two species, the first with two smooth, shining valves, the second with the left valve finely concentrically striated and the right with obsolete radials. That this was so can be proved by several lines of evidence. Thus his figures, supposed to show a right and a left valve are really of two right valves. Also in his description he says the left valve is "laevigata, interdum striis concentricis ornata." This includes the two species, for the shell with a radially ribbed right valve always has a concentrically striated left valve, not a smooth one; though, as pointed out to me by Dr. Finlay, this could refer to weathered material of the ribbed species. The localities given by Zittel are Whaingaroa and Aotea, Auckland; and Cape Farewell, Nelson. At Whaingaroa and Aotea both species occur, but at Cape Farewell only the smooth shell is found. The evidence of the localities alone shows that two species were confused; and since the locality is a vital part of a description, it cannot be assumed that Zittel's description applies to only one species. Further, Zittel said that the left valve was smooth or concentrically striate, and the right valve weakly ribbed. The statement, as it stands, applies to the ribbed shell accurately enough; but quite possibly this agreement is apparent only. Whether Zittel regarded the byssal notch as anterior or posterior is not clear. At the time he wrote, opinion was divided on the subject, and the descriptions of other species in the "Novara" publication are not conclusive. The evidence afforded by *P. athleta*, however, seems to indicate that Zittel's left valve was what we call the right. Also, fig. 5a of *P. hochstetteri*, said by him to be a left valve, shows the byssal sinus plainly, whereas in the original of fig. 5b the ears are badly broken. This tends to show that the smooth right valve figured by Zittel was used by him for his description of the supposed "left" valve, and was not mistaken by him for a true left valve in the modern sense. At all events, there can be no doubt that Zittel handled two species and that his description and figures include both. Therefore, when Hutton (1873, p. 30) selected the shell with two smooth valves as *hochstetteri* and expressly excluded the ribbed shell he was quite within his rights, and the choice cannot be altered. His reference is "Zittel, Voy. Novara, Palae., p. 50, pl. XI, f. 5a, not 5b." This course was approved by Tate (1886, p. 114) who correctly stated that the shell having a ribbed valve was apparently related to *P. yahlensis* T.-Woods.

Hutton's deliberate choice of the smooth shell for *P. hochstetteri* was overlooked by Park (1905, p. 485) who took it for granted that *P. hochstetteri* should refer to the ribbed one (Zittel, pl. 11, f. 5b)

and gave the name *Pseudamussium huttoni* to the smooth. *P. huttoni* is therefore a synonym of *P. hochstetteri* and the latter must be used. The species with a weakly-ribbed right valve and a concentrically-lined left one being without a name, *Serripecten polemicus* is proposed, and a specimen from loc. 993, coast, section 70, block 19, Whaingaroa Survey District, is chosen as type.

The origin and relationships of *P. hochstetteri* are not clear. The small, smooth, Cretaceous shell identified by Woods as *P. membranaceus* Nilss. has no byssal notch, but otherwise closely resembles *P. hochstetteri*, and may well be ancestral. On the other hand it is possible that the smooth valves result from obsolescence of sculpture as in *Janupecten*; but more collecting is needed to settle this point. Suter's species *P. waihaoensis* is almost certainly closely related to the *P. hochstetteri* stock, for the ribs in the right valve are extremely weak, though whether obsolete or rudimentary cannot be determined. Perhaps a connection exists through this species with *P. devinctus*.

Occurring in the same locality as *P. waihaoensis*, i.e., Waihao Downs (Eocene) is an unnamed species with both valves smooth, and at McCullochs Bridge is yet another species distinct from *P. hochstetteri*. Probably many other species exist in the Oligocene and Miocene of New Zealand and have been lumped in with *P. hochstetteri*; but much more material is required to make satisfactory divisions. For the present, it is advisable to treat all New Zealand Tertiary Pectens with two smooth valves as belonging to one generic stock, though it is not certain that they do. For this group the new genus *Lentipecten* is proposed with type *Pecten hochstetteri* Zittel (Pl. 11, fig. 5a, as limited by Hutton = *P. huttoni* Park).

The prominent ribbing on the left valves of *P. waihaoensis* and *P. imperfectum* seems worth subgeneric recognition so *Duplipecten* is proposed, with type *P. waihaoensis* Suter.

Suter apparently thought that the two valves of *waihaoensis* figured by him belonged to one individual, for his MS. label with them has the word "holotype" on it. We do not know what is the evidence for his opinion, and possibly another species related to *L. hochstetteri* is represented by the fragmentary right valve. Therefore the left valve (Suter, 1917, pl. 7, fig. 15) is here designated lectotype of *P. waihaoensis*.

The Chatham Island Tertiary *P. hectori* has no known close relatives in the New Zealand region, but it agrees very well with the east North American *Placopecten*. This resemblance might be due to convergence, but since there is no evidence to connect *P. hectori* with any species of the south-west Pacific, *Placopecten* can be used, at least until more is known on the subject.

Until now, all internally-ribbed shells in Australia and New Zealand have been called *Pecten*, or *Amussium*, *zitteli*; but there are two quite distinct groups in the Tertiary of both countries. One has both valves similar and almost smooth with subequal ears not showing a byssal sinus, whereas the other has discrepant valves, the left with well-marked radial sculpture and the right with concentric only, also the byssal notch is well developed. Hochstetter (1864, p. 53, pl. 19, figs. 1b, 3 under *Pecten* sp. described the cast of a shell with

obtusely angled ears from Papakura (30 mm. high according to the figure). Later, on the same page, he mentioned a small shell from Orakei Bay (8 mm. high) as perhaps belonging to the same species. An internal cast was figured (pl. 9, fig. 1b) and on the same block are four other shells of similar size. Three of these are smooth, and one indicates by the unequal ears that it is a right valve. They were named *P. aucklandicus*. The remaining specimen shows the exterior of a shell with radial ribs and ears of about the same size as those of the *Amussium* and the *P. aucklandicus*. Zittel thought it might be *P. fischeri*, but neither the apical angle nor the number of ribs corresponds. The right ear is shown in the figure slightly larger than the left, but the shell is probably not a right valve for there is no sign of a byssal notch. This brings us to the question of whether all these shells might not belong to one species of *Variamussium*. Only an examination of the type or of topotype material will settle this.

Hutton (1873, p. 32), with material from several localities, gave the name *Pecten zitteli* to these internally-ribbed shells and referred to Zittel p. 53, though not to any figure. He described the shells as smooth and with ears equal and obtuse, height 0.85 inch (= 22 mm.).

Tate (1886, p. 115, pl. 7, figs. 3 a-e) ascribed to *P. zitteli* Hutton specimens from five Australian localities, giving as dimensions 10 mm. x 9.5 mm. His excellent material showed discrepant sculpture on the two valves, so he gave a full description and figures, and thought that Hutton was wrong in saying that both valves were smooth.

The type of *P. zitteli* was not chosen until Suter (1914, p. 44, pl. 6, figs. 5 a, b) selected Hutton's specimen from Whangape Lake. The figure published by Suter is from an old, idealized drawing by Buchanan, probably from the type which has the measurements given by Hutton. The valves are not smooth, however, having fine concentric sculpture, but there are no external radials. Suter's description is only a quotation of Tate's, following that author's mistaken idea of which was the right and which the left valve. It is therefore based on a shell quite different from *A. zitteli* and requiring a new name.

Tate was right in saying that some New Zealand shells showed discrepant sculpture, but they are without a name unless indeed they are Zittel's *P. aucklandicus*.

The true *P. zitteli* appears to agree with *Parvamussium* Sacco; but I have not had access to Sacco's work or to specimens of the genotype, *P. duodecimlamellatus* Bronn.

The shells with discrepant sculpture can be classed as *Variamussium* Sacco type *Amussium cancellatum* E. A. Smith (*vide* Cossmann. Dall, following Verill and Busch, gave "Schmidt" and could not identify the shell).

Clarke's species *A. papakureense*, established because of the inequilateral shape, may be the same as *A. zitteli*. The present shape is probably due in large part to rock distortion.

Much confusion exists as to the spelling of *Amussium* and the many derived words such as *Pseudamussium*, *Parvamussium*, etc. Bolten's original spelling is *Amusium*, and this form has been followed by Dall and most modern American writers. Many European authors,

however, including those who introduced most of the derived words, used the double 's.' For the sake of uniformity Dall altered the compound words to agree with Bolten's spelling; but since the correct spelling of the Latin word is *Amussium* (a wheel to indicate wind direction) it would surely be better to recognise the emendation of Bolten's usage.

Hutton's type of *Hinnites trailii* has been recovered. It is a left valve agreeing closely with the shells not uncommon at Target Gully. The sculpture is finer than that of the genotype of *H. crispus* Brocchi; but the other shell-characters show that we are dealing with a true *Hinnites*. The muscle-scar is large and circular, the pallial impression is of small diameter, the resiliary pit is long and narrow, and there are no hinge-crura. The genus is known in New Zealand only in the Awamoan stage, i.e., approximately Lower Miocene.

Finlay (1926, p. 452) has proposed *Cycloclamys* for the recent *Cyclopecten transenna* (Suter), at the same time admitting as true *Cyclopecten* an unnamed species. Dr. Finlay kindly forwarded his material for re-examination and wrote that the single right valve on which his description was based could not be found and was probably broken. He felt pretty sure, however, that it really was a right valve for he had gone into the matter carefully. Nevertheless it seems likely that a mistake was made. From the type locality there are two smooth right valves which have a damaged posterior ear, without a separating groove, and a large scaly-ribbed, deeply-notched, anterior one, and for which no left valve, unless *C. transenna*, have been found. Also, from shell-sand, Mason's Bay, Stewart Island, Mr. A. W. B. Powell has separated left valves of *transenna* and right valves as described above. In these the posterior ear is shown to be large, but not defined by a groove, the posterior edge of the shell being almost vertical. The evidence is fairly conclusive that these are indeed the right valves of *C. transenna*, which consequently agrees with *Cyclopecten* in general character. Whether *Cycloclamys* can be retained as a division of *Cyclopecten* had perhaps better be settled by a comparison of actual specimens.

#### Summary of N.Z. Pectinidae.

##### 1. Genus *PECTEN* Mueller, 1776.

Type: *Ostrea maxima* L.

Subgenus *Notovola* Finlay, 1926.

Type: *P. novaezelandiae* Reeve.

\**novaezelandiae* Reeve.

##### 2. Genus *Chlamys* Bolten, 1798.

Type: *Pecten islandicus* Mueller.

Subgenus *Chlamys* s. str.

\**campbellicus* Odhner 1924. \**celator* Finlay 1927, *chathamensis* (Hutton), \**consociata* E. A. Smith 1915, *delicatula* (Hutton), \**dichrous* (Suter), *fischeri* (Zittel), \**imparicostata* (Bavay), *mercuria* n. sp., *oamarutica* Murdoch 1924, \**radiata* (Hutton), ? *scandula*

(Hutton) not seen, *seymouri* n. sp., \**suprasilis* Finlay 1927, *titi-rangiensis* n. sp., *venosa* (Hutton), *Chlamys* sp. (Trechmann) Triassic.

3. Genus *PALLIUM* Schumacher, 1817.

Type: *Pecten plica* Lamarek.

? Subgenus *Felipes* Locard.

Type: *Ostrea pesfelis* Linné.

*burnetti* (Zittel), \**convexum* (Q. and G.), *costato-striatum* (Marshall), *dendyi* (Hutton), *kaiparaense* (Finlay) 1924 (= *P. subconvexus* Marshall), *marionae* (Finlay) (= *semi-plicatus* Hutton), ? *polymorphoides* (Zittel); *syagrus* (Marwick) 1924.

4. Genus *SECTIPECTEN* nov.

Type: *Pecten wollastoni* Finlay (= *Pecten sectus* Hutton).

(1) Subgenus *Sectipecten* s. str.

Shell large, strong, subequilateral, both valves inflated, right sometimes more than the left; ears large, subequal, byssal sinus restrained, no etenolium. Sculpture: right valve with about eight strong, rectangular folds separated by somewhat narrower, flat interspaces. The ribs later on divide, but the divisions remain grouped together and raised above the interspace which by now has developed one to three secondary ribs. Left valve with about eight strong ribs with much wider, flat interspaces. The ribs are generally grooved down the middle, sometimes deeply so and appear as double ribs. Secondary grooves are also developed, and in the interspaces are from two to five riblets. The whole surface except the flat summits of the ribs in the right valve with crowded, fine, regular, sharp concentric ridges. Hinge-erura scarcely developed.

*allani* n. sp., *crawfordi* (Hutton), *devinctus* (Suter), *diffluxus* (Hutton), *wollastoni* Finlay.

(2) Subgenus *Athlopecten* nov.

Type: *Pecten athleta* Zittel.

Shell large, strong, equilateral, ears large, subequal, byssal notch deep and wide, no etenolium. Sculpture: right valve with about 11 low rounded radials, left with double the number of much narrower, paired ribs, interspaces with secondaries appearing during growth. Sharp, irregular concentric lamellae on ears and distal parts of shell. *athleta* (Zittel), *marshalli* (Suter).

5. Genus *PHIALOPECTEN* nov.

Type: *Pecten triphooki* Zittel.

Shell large, equilateral, right valve flat, left valve well inflated. Ears large, subequal; byssal notch narrow but well marked, no etenolium. Sculpture: both valves with twenty to thirty strong, rounded ribs with narrow interstices. The ribs soon develop a weak central groove and the interstices a central thread, sometimes these increase in number until the whole surface is faintly corrugated.

The interstices and the sides of the ribs are crowded by fine regular sharp concentric ridges.

*accrementus* (Hutton), *hilli* (Hutton), *triphooki* (Zittel).

#### 6. Genus *SERRIPECTEN* nov.

Type: *Pecten hutchinsoni* Hutton.

##### (1) Subgenus *Serripecten* s. str.

Shell fairly large, equilateral; right valve more inflated than left; ears subequal, right anterior one slightly larger than posterior. Sculpture: right valve with over thirty strong, sharp, scaly, bevelled ridges, often with a scaly secondary thread in the interstices. Left valve with about seventy scaly threads, many of which have appeared during growth.

*beethami* (Hutton), *enfieldensis* (Marwick), *hutchinsoni* (Hutton), *tiorioriensis* n. sp.

##### (2) Subgenus *Januipecten* nov.

Type: *Pecten uttleyi* Marwick.

Shell of moderate size, equilateral, equivalve; ears subequal, those of right valve ascending distally; byssal notch well developed, no ctenolium. Sculpture: right valve with over fifty weak radials, bevelled towards extremities; left valve smooth, or concentrically lined, sometimes with obsolete radials appearing distally.

*polemicus* n. sp. (= *hochstetteri* of Park not of Hutton), *uttleyi* (Marwick).

#### 7. Genus *LENTIPECTEN* nov.

Type: *Pecten hochstetteri* Zittel, pl. 11, fig. 5a.

(= *Pseudamussium huttoni* Park.)

##### (1) Subgenus *Lentipecten* s. str.

Shell of moderate size, equilateral, equivalve, gaping; ears subequal, separated from valve by only shallow groove, those of right valve ascending distally; byssal notch well developed, no ctenolium. Both valves smooth and shining, with traces of very fine concentric lines. Interior smooth.

*hochstetteri* (Zittel).

##### (2) Subgenus *Duplipecten* nov.

Shell of moderate size, equilateral, equivalve, gaping; ears subequal, those of right valve ascending distally on dorsal margin, and separated below from disc by channel; byssal notch well developed, no ctenolium. Right valve almost smooth, with faint, spaced radials. Left valve with broad, low, spaced radials which show weakly internally.

*waihaoensis* (Suter), *imperfectus* n. sp.

#### 8. Genus *PLACOPECTEN* Verrill 1897.

Type: *Pecten clintonius* Say.

*hectori* (Hutton).

## 9. Genus PSEUDAMUSSIUM H. and A. Adams, 1858.

Type: *Pecten pseudamussium* Sowerby  
(= *exoticus* Chemnitz).

? *membranaceus* (Nilsson), ? new sp. Upper Senonian; ? *Pseudamussium* sp. (Trechmann) Jurassic.

## 10. Genus CAMPTONECTES Meek, 1864.

Type: *Pecten lens* Sowerby.

cf. *lens* (Sowerby) Jurassic; *Camptonectes* sp. (Woods) Albanian; *selwynensis* Finlay Upper Senonian.

## 11. Genus SYNCYCLONEMA Meek, 1876.

Type: *Pecten halli* Gabb (= *P. rigida* Hall and Meek).

? *Syncyclonema* sp. (Woods) Albanian.

## 12. Genus MIXTIPECTEN nov.

Type: *Pecten (Aequipecten) amuriensis* Woods.

Shell small, right valve almost flat, left well inflated; ears large, subequal, not ascending, joining disc without channel; byssal notch very deep. Sculpture: right valve almost smooth, with a few weak radials at extremities; left valve with many narrow but strong primary radials with wide flat interspaces which are sometimes traversed by a secondary radial, and which have somewhat irregular, spaced, concentric ridges.

*amuriensis* (Woods).

## 13. Genus CYCLOCHLAMYS Verrill, 1897.

Type: *Cyclopecten pustulosus* Verrill.

\**secundus* (Finlay), \**transeenna* (Suter).

## 14. Genus PARVAMUSSIUM Sacco, 1897.

Type: *Pecten duodecimlamellatus* Bronn.

*zitteli* (Hutton), *papakureense* (Clarke) (perhaps = *zitteli*).

## 15. Genus VARIAMUSSIUM Sacco, 1897.

Type: *Amussium cancellatum* E. A. Smith.

*Variamussium* spp. unnamed, or ? *aucklandicus* (Zittel).

## 16. Genus HINNITES Defrance, 1821.

Type: *Ostrea crispa* Broochi (= *Hinnites cortesyi* Defrance).

*trailli* Hutton.

**Chlamys chathamensis** (Hutton). (Figs. 18, 19.)

1873. *Pecten chathamensis* Hutton, *Cat. Tert. Moll.*, p. 29.

Shell somewhat small, thin; both valves moderately inflated. Ears very unequal. Sculpture: right valve with about 17 rather narrow, strong, scaly ribs with wider interstices; on each flank of the ribs, beginning some distance from the umbo is a weak scaly thread;

anterior ear with 5 strong scaly ribs; posterior ear very small, with about 4 weak, well spaced scaly ribs. Left valve similar to the right, but with about 20 ribs; a few posterior ones noticeably weaker; anterior ear with fairly straight outer edge, with 7 weak well-spaced scaly ribs a secondary in the two top interspaces; posterior ear with about 4 weak, widely spaced scaly radials.

Height 26 mm., length 22 mm., inflation (1 valve) 4.5 mm.

Localities: Flower-pot Harbour, Pitt Island; Momoe-a-toe.

Hutton gave as localities for his species "Chatham Islands; Castle Point, East Coast, Wellington; Broken River (L)," and when Suter (1914, p. 40, pl. 6, fig. 6) revised the old Geological Survey collection, he named the specimen from Broken River as type. This does not seem correct procedure, because the specific name *chathamensis* should by tautonymy be reserved for the Chatham Islands shell. Therefore a neotype (Fig. 18) from Flower-pot Harbour has been selected.

The strength of the scales on the ribs varies considerably, some specimens being almost smooth.

### ***Chlamys seymouri* n. sp. (Fig. 23.)**

Shell large, thin, compressed, subcircular, slightly oblique. Apical angle acute, widening with age. Ears very unequal, anterior sinus deep. Sculpture: right valve with about 18 narrow primary ribs with very wide concave interstices with 8 and 10 or even more, scaly riblets of which two are often stronger than the others, these two appear on the sides of the primaries about 10 mm. from apex and the others follow later, their relative strength corresponding with their time of appearance; anterior ear with 4 scaly radials; posterior with 8. Left valve with about 20 narrow primaries, the wide concave interstices with two secondaries sometimes almost as strong as the primaries, each secondary interspace with 3 to 7 scaly riblets of irregular strength; anterior ear with about 15 spaced scaly radials of which 6 are stronger than the others, posterior with about 10.

Height 77 mm., length 73 mm., thickness (1 valve) 10 mm.

Localities: 1176, Momoe-a-toa; (?) Whenuataru Peninsula.

Remarks: Sometimes the primaries are smooth and much stronger than the interstitial riblets, giving the shell a resemblance to *C. delicatula* which, however, has more ribs. At other times the strength of the ribbing is very regular, making the shell look like a large *C. radiata*. Small specimens are often indistinguishable from *C. radiata* except by the vertical outer edge of the left anterior ear. *C. seymour* is a development of *C. chathamensis* in which there are many additional secondary riblets, all the radials having strong scales.

### ***Chlamys mercuria* n. sp. (Fig. 17.)**

Shell small, ovate, strong, inflated, equilateral; ears very unequal; apical angle acute; right valve with 21 smooth, rounded, rather flat ribs with narrower interstices strongly marked with *Camptonectes* striation, anterior ear with a broad rib above and a narrow one below, left valve with about 22 radials narrower and stronger than those of right valve, interstices similarly striated.

Height 13 mm.; length 12 mm.; thickness (1 valve) 2.5 mm.  
Locality: Waikaripi, below Wireless Station, Waitangi.

***Chlamys titirangiensis* n. sp. (Fig. 28.)**

Shell of moderate size, subcircular, slightly inequilateral, apical angle about 95°, ears very unequal. Sculpture of right valve consisting of about 40 strong radial ribs many of them arranged in pairs and some double, the posterior and anterior ones noticeably finer; interstices somewhat narrower than the ribs and often with a central thread. Scaly concentric ridges are well developed in the interstices but are absent on the summits of the ribs (this may be due to wear). Anterior ear with five radials interstices crossed by spaced scaly ridges.

Height 37 mm.; length 36 mm.; thickness (1 valve) 6.5 mm.  
Locality: Titirangi.

***Pallium dendyi* Hutton. (Fig. 29.)**

1902. *Pecten dendyi* Hutton, *Trans. N.Z. Inst.*, vol. 34, p. 196, pl. 8.

1915. *Pecten (Chlamys) dendyi* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull.* 3, p. 52.

The number of primary radial ribs is variable. Hutton's type with 9 in right valve and 8 in left is perhaps the commonest. On right valve the four strong central ribs are arranged in two pairs, each of which sometimes has the form of a single, broad rib with only a shallow indentation down centre. It is then extremely like *P. convexum*. In these cases, as a rule, the secondary ribbing is not strongly developed. The anterior primary rib in right valve is often not developed. The first or anterior rib is sometimes absent from left valve and there is considerable difference in strength of 6th rib.

Holotype in Canterbury Museum.

Dimensions of plesiotype, height 66 mm.; length 70 mm.; thickness of both valves 27 mm.

Locality: Momoe-a-toa.

***Serripecten tiorioriensis* n. sp. (Fig. 14.)**

Shell rather small, fragile, subcircular, compressed, apical angle obtuse, inflation moderate, right probably more inflated than left; ears unequal; right valve with about 38 narrow, smooth, rounded ribs with smooth interstices of equal or slightly greater width. About 30 mm. from apex, ribs become sharp and scaly and a scaly riblet appears in each of the interstices, anterior ear with 5, posterior with 6 strong radials.

Height 41 mm.; length 42 mm.; thickness (right valve) 6 mm.  
Locality: Tioriori.

Five good specimens were collected but all are right valves, consequently the left valve is unknown. The species is closely related to *Serripecten hutchinsoni*, but is much more primitive as the characters showing most resemblance appear at a late stage. It is at about the same stage as *S. enfieldensis* Marwick from the Waiarekan tuffs but has more primary ribs.

**Sectipecten allani** n. sp. (Figs. 13, 21.)

Shell large, strong, subcircular, apical angle obtuse, both valves inflated, right more than left. Ears unequal, anterior sinus shallow. Sculpture somewhat variable; type has in right valve 9 broad flat ribs, separated by interstices about half their width, the ribs have vertical sides and so their cross section is quadrangular, on their surfaces are faintly impressed from four to six broad secondary ribs. Interspaces have one strong narrow median rib throughout nearly the whole length, with weak one on each side coming in later. On anterior and posterior distal portions of disc are about five narrow radial riblets. Whole surface is covered with fine regular concentric ridges which in rib interspaces and on ears become much stronger and sharply raised, posterior ear with three obsolete, widely-spaced radials, anterior with 4 strong spaced radials and some secondaries. Left valve with 9 rather narrow, strong, rounded primary ribs which are weakly divided from about one inch from apex, some ribs have indications of still further division of each half. Interspaces are twice as wide as ribs, corresponding to the ribs of right valve; each has from 3 to 4 strong, rounded, secondary riblets, whole surface including ribs and ears covered by dense, sharp raised concentric growth-ridges; each ear with about 3 obsolete radial threads.

Height 98 mm.; length 104 mm.; thickness of right valve 13 mm.; left valve 10 mm.

Locality: 1176, Momoe-a-toa.

Remarks: This is the largest and probably the commonest shell in the *Pecten* bed at this place. Some specimens reach 120 mm. in diameter. The inflated specimens have generally strong primary but weak secondary ribbing. Other shells have on the right valve rather weak primaries which are divided almost up to the apex, one or both limbs being grooved. These variations approach *Sectipecten wollastoni* Finlay (= *sectus* Hutt.); but in no case is strong primary ribbing accompanied by deep secondary grooving. The two species are closely related, but *S. allani* seems to be the less advanced, for the inflated adults are at about the stage represented by *S. wollastoni* of 30 mm. diameter.

**Sectipecten toaensis** n. sp. (Fig. 16.)

Shell rather small for the group, subcircular, somewhat compressed, apical angle  $90^\circ$ , valves almost equal, ears unequal, right valve with 33 strong regular quadrangular ribs separated by interstices of equal width, about 3 weak radial riblets anterior to primaries, interstices and sides of ribs crowded with sharp concentric ridges, near apex are shallow folds so weak that the number is uncertain, left valve with 35 somewhat irregular quadrangular ribs, there are 7 or 8 very weak folds the central one strongest, on summits of these folds the ribs are stronger than in interspaces, anterior ear with 6 sharp rough spaced radials, posterior with 7 smooth ones the top two stronger than others.

Height 49 mm.; length 47 mm.; thickness (l.v.) 9 mm., (r.v.) 8 mm.

Locality: Momoe-a-toa.

Remarks: Related to *Sectipecten crawfordi* which has the folds well developed and more ribs.

**Placopecten hectori** Hutton.1878. *Pecten hectori* Hutton, *Cat. Tert. Moll.* p. 30.1887. *Pecten yahlensis* Tenison-Woods: Hutton, *P.L.S., N.S.W.* (2) vol. 1, p. 235.1914. *Pecten* (*Pseudamysium*) *yahlensis* Tenison-Woods: Suter, *N.Z. Geol. Surv. Pal. Bull.* 2, p. 43, pl. 7, fig. 3.1924. *Pecten hectori* Hutton: Marwick, *Rep. A.A.A.S.* vol. 16, p. 326, pl. 6, fig. 1.

The sculpture of the left valve is similar to that of the right, i.e., numerous radial incised lines separating sometimes broad interspaces, sometimes narrow ribs

Locality: Flower-pot Harbour, Pitt Island.

Fragments of a large *Pecten* with a great number of radial ribs were collected from the bryozoan, tuffaceous limestone at Waitangi. This may be a left valve of *P. hectori*.

**Lentipecten (Duplipecten) imperfectus** n. sp. (Figs. 30, 31.)

Shell rather small, fragile, subcircular, apical angle obtuse. Both valves equally and moderately inflated. Ears probably subequal. Right valve practically smooth, with microscopic "*Camptonectes*" radials; left valve with about 50 smooth, low, broad, radial ribs with narrow interstices showing *Camptonectes* striation.

Height 27.5 mm.; length 27 mm.; thickness (both valves) 8 mm.

Locality: Tioriori.

The classification under *Lentipecten* is tentative for there are several points of disagreement, e.g., sculpture and shape of the ears.

Genus *LIMA* Cuvier, 1798.

Type: *Ostrea lima* Linné.

**Lima vasis** n. sp. (Fig. 38.)

Shell large, but rather thin, little inflated, beaks low. Posterior ear fairly large. Sculpture of 22 narrow but strong, rounded ribs separated by concave interstices at first equal to the ribs but rapidly widening until they are about three times as wide, the ribs flatten out towards the margin, concentric lines rather stronger on the crests of the ribs and on the posterior ear which has two weak radial threads.

Height (estimated) 80 mm.; length (estimated) 65 mm.; thickness of 1 valve 14 mm.

Locality: Flower-pot Harbour, Pitt Island.

Genus *LIMATULA* Searles Wood, 1839.

Type: *L. subauriculata* Montagu.

**Limatula maoria** Finlay.

1913. *Lima* (*Limatula*) *bullata* Born: Suter, *Manual N.Z. Moll.*, p. 886, pl. 58, fig. 13.

1926. *Limatula maoria* Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 454.

Locality: Titirangi.

The single specimen has a rather broad hinge.

**Limatula morioria** n. sp. (Fig. 35.)

Shell of moderate size, oval, inflated, equilateral, beaks broad, ears inconspicuous. Sculpture of 29 sharp ribs with wide concave interspaces the central ribs are strong and erect the pair on each side of the median line rather closer together, the lateral ribs are low and oblique but well spaced; sharp close concentric ridges cross the interstices and surmount the ribs rendering their edge dentate. Valve-margin crenulated.

Height 18 mm.; length 12 mm.; thickness (1 valve) 6 mm.

Localities: Momoe-a-toa (type); Whenuataru Peninsula; Flower-pot.

Remarks: Distinguished from *L. maoria* Fin., by the less attenuated shape and persistence of the broad ribbing along the sides. There is no trace of the fine crowded anterior and posterior ribs of *L. maoria*.

Genus CTENOIDES H. and A. Adams, 1858.

Type: *Lima scabra* Born.

**Ctenoides naufragus** n. sp. (Figs. 36, 37.)

Shell ovate, slightly inequilateral, inflated. Ears small, almost equal, right somewhat lower and stretching further down shell than left, broadly and deeply sinused for the byssus. Sculpture of from 50 to 55 low, slightly-bevelled, weakly-beaded undulating ribs divaricating from a line somewhat in front of middle of disc; some ribs more especially posterior ones divide on nearing margin; interspaces about as wide as ribs and have fine undulating, oblique threads somewhat resembling anastomosing finger-prints. Four narrow radials on posterior ear but only growth-lines on anterior one. Ligamental area somewhat narrow and short with well marked central pit. Close below area on each side is a small tubercle, and inner margin at base of each ear has another.

Height 28 mm.; length 23 mm.; inflation (1 valve) 7.5 mm.

Locality: Flower-pot Harbour, Pitt Island.

A solitary right valve of this interesting Northern genus was found by Mr. Allan. Undescribed species occur at Pakaurangi Point and Palliser Bay.

Genus LIMEA Broun, 1831.

Type: *Ostrea strigilata* Brocchi.

**Limea chathamensis** n. sp. (Figs. 33, 34.)

Shell rather small, thin, oblique, suboval, well inflated, beaks not much raised above the hinge-margin, ears small, surface with about 45 ribs, the anterior 12 broad and very low and with linear interstices, those on centre of disc strong and sharp with concave interspaces in each of which is a weak thread, ribs flatter and wider on posterior; hinge margin broken away, but with about 5 anterior and 5 posterior weak taxodont teeth, valve-margin crenate.

Height 14 mm.; length 12 mm.; thickness (1 valve) 4.5 mm.

Locality: Momoe-a-toa; Whenuataru Peninsula.

Iredale (1924, p. 194) has recently proposed *Notolimea* for the Australian *L. australis* Smith, but owing to lack of specimens the writer is not able to say on what differences the new genus is founded.

Genus *OSTREA* Linné.Type: *O. edulis* Linné.***Ostrea cannoni* n. sp.** (Figs. 32, 41.)

Shell large, solid, suboval, generally equilateral, rather flat, surface of attachment very large (60 mm. diameter in type). Sculpture of left valve consisting of irregular, discontinuous, waved radial folds which are intersected by a few strong, spaced, puckered, concentric lamellae, numerous crowded fine lamellae towards margins. Ligamental area very large, traversed by fairly deep, concave, triangular pit, about one-third of the total area. Muscular scar oval, nearer the ligamental margin. Valve-margins smooth.

Height 132 mm.; length 128 mm.; thickness (left valve) 50 mm. Maximum thickness of shell material 28 mm.

Locality: Tioriori.

***Ostrea waitangiensis* n. sp.** (Fig. 26.)

Shell fairly large, not heavy, kidney-shaped, with an anterior wing. Surface of attachment moderate. Left valve moderately convex, right valve concave. Sculpture, left valve with short, discontinuous irregular radials, 2-4 mm. wide, developed mostly on the posterior side; and irregular, spaced, concentric lamellae averaging perhaps 15 mm. apart. Right valve with an irregular, puckered surface. Ligamental area destroyed in the single specimen; valve-margins broadly folded.

Height 108 mm.; length 100 mm.; thickness (both valves) 38 mm.

Locality: Cliffs south of Wireless Station, Waitangi.

***Ostrea arcula* n. sp.** (Figs. 42, 43.)

Shell of moderate size, subquadrate, winged posteriorly, beaks inconspicuous. Left valve with a very large area of attachment where it is considerably thickened, but tapers rapidly to a knife-like margin; right valve thin, slightly convex at first but with a deep concavity towards outer border. Surface almost smooth, slightly lamellate towards margins, vaguely puckered postero-ventrally. Ligament triangular, moderate, directed obliquely backward, with a narrow median groove

Height 40 mm.; length 40 mm.

Locality: Monoe-a-toa.

Genus *NOTOSTREA* Finlay, 1928.Type: *Ostrea subdentata* Suter.***Notostrea tarda* (Hutton).** (Figs. 86-96.)

1873. *Gryphea tarda* Hutton, *Cat. Tert. Moll.*, p. 35.

1914. *Gryphea tarda* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull.* 2, p. 47, pl. 13, figs. 1a, b.

Localities: Bryozoan limestone, Tioriori; limestone boulders at head of Whangamoe Inlet (wrongly named Whangatete on L. and S. map, 1910); base of tuffaceous limestone, Waikaripi.

Many specimens were collected at what is probably the type locality at Tioriori where they occur in great numbers. The speci-

mens figured are not exceptional ones, but give a fair idea of the great range in width and incurving. The writer is indebted to Dr. H. J. Finlay for drawing his attention to the close relationship between *Gryphaea tarda* and *Ostrea subdentata* Suter, and for questioning the use of *Gryphaea* for Hutton's species. Trueman (1922, p. 264) writing on *Gryphaea* of the Lower Lias, had previously pointed out that this genus is based on form alone and does not represent a genetic line. He says, "It is extremely likely that these gryphaeiform shells have been evolved repeatedly during the Jurassic and Cretaceous from species of *Ostrea* that are similar and are presumably closely related. In other words '*Gryphaea*' is a polyphyletic group, containing species evolved along many different lines. Therefore, the name *Gryphaea* can only be applied strictly to one of these series, and each such series should receive a separate generic name; but until more of their characteristics are known, at least, it appears undesirable to add to the existing confusion by creating new names for each group." This objection does not apply to the Tertiary *Notostrea* of Finlay which is not likely, in New Zealand, to be confused with any other "*Gryphaea*," for none of these shells have been found in the Mesozoic of this country. However, the question of whether the South American and South Australian Tertiary examples should be classed as *Notostrea* arises. It seems likely that they also have arisen each independently in their own seas and do not indicate genetic connection.

The writer formerly thought (Ferrar, 1925, p. 295) that the posterior position of the adductor muscle, and the well-developed posterior lobe with its bounding groove showed relationship between "*Gryphaea*" *tarda* and the Jurassic *G. arcuata* Lam., but had to change his opinion after seeing some specimens of *Ostrea charlottae* Finlay from Castlecliff. These have the typical sculpture of ordinary *charlottae* but in shape, size, and other features agree with the moderately-curved specimens of *tarda*. The right valve is correspondingly modified and is extremely like the one figured below (Figs. 94-96).

It may be mentioned in passing that, following Fisher. Cossman (1914, p. 389) gives the recent *G. angulata* Lamarek as the type of *Gryphaea*, and recognizes *Liogryphaea* Fischer, founded on the Jurassic *G. arcuata* Lam. Dall, however (1898, p. 673) had previously shown that when *Gryphaea* was introduced in 1801, *G. angulata* was a *nomen nudum* and therefore without status. He argued rightly that the type must be chosen from the valid species of Lamarek's original list and named *G. arcuata* Lam. as genotype. *Liogryphaea* Fischer is therefore an absolute synonym of *Gryphaea* Lamarek.

Genus NEOGAIMARDIA Odhner, 1924.

Type: *Kellia rostellata* Tate.

*Neogaimardia elegantula* n. sp. (Figs. 39, 40.)

Shell minute, subovate, with short angled anterior end and long, oval posterior one. Surface polished, with microscopic concentric lines; about half way from umbo commence fine, rounded concentric folds. Left hinge with an ogee-shaped tooth in front of the umbo,

and an obliquely-triangular resilifer extending backwards from below it. Above and behind the resilifer is a long posterior lateral tooth practically parallel to the margin but approaching it in one place and suggesting that this tooth is a coalescence of two previously independent ones. Valve-margins smooth.

Height 2 mm.; length 2.5 mm.; inflation (1 valve) 0.75 mm.

Locality: Titirangi.

The shell figured by Odhner (1924, p. 69, pl. 2, fig. 57, text figs. 17-19) as *N. rostellata* Tate is of a different shape from Tate's original (1889, p. 63, pl. 11, fig. 14) and the specific identity of the Australian and New Zealand specimens is denied by Finlay (1926, p. 458). *N. elegantula* is of a different shape again, being more inequilateral than the South Australian shell and lacking the suddenly-expanded beak of the New Zealand one.

Genus CUNA Hedley, 1902.

Type: *C. concentrica* Hedley.

*Cuna firma* n. sp. (Figs. 56, 57, 58.)

Shell minute, ovate, beaks very high, about anterior third, curved strongly forward; anterior end regularly convex, somewhat descending above; dorsal margin long, curved, descending steeply to the regularly convex posterior margin, basal margin regularly convex. Lunule large, shallow, not marked off. Sculpture of about 10 very low, broad ribs with linear interstices crossed by numerous strong growth-lines. Hinge-plate broad; right valve with thin weak anterior cardinal tooth slightly diverging from the lunular margin; a strong, weakly-grooved triangular median cardinal joined for half its length to a thin, oblique posterior one. Left valve with two diverging cardinals the anterior fairly thick and high, the posterior thinner and lower. Ligamental margin slightly depressed near umbo, forming with the produced and recurved lunular margin in right valve a deep notch. Valve-margin crenate.

Height 3 mm.; length 2.3 mm.; thickness (1 valve) 1 mm.

Locality: Titirangi.

*Cuna antiqua* n. sp. (Figs. 54, 55.)

Externally similar to *C. firma* but with about 14 instead of 10 ribs. Right hinge: anterior lateral represented only by a slight thickening of the lunular margin; median cardinal strong, triangular; posterior cardinal thin, short, almost horizontal, well separated from the median. Ligamental margin very slightly depressed near umbo, separated from lunular margin by a notch. Valve-margins crenate.

Height 3 mm.; length 2.5 mm.; thickness (1 valve) 1 mm.

Locality: Whenuataru Peninsula, Pitt Island.

Genus CARDITA Lamarek, 1799.

Type: *Chama calyculata* Linné.

*Cardita northcrofti* n. sp. (Figs. 44, 46.)

Shape and sculpture as in *C. aoteana* Finlay. *C. northcrofti* is easily distinguished from the Recent shell by the lunule and its effect on the hinge. In *C. aoteana* the lunule is convex only in the very

young stages. In the adult it slopes obliquely downwards and backwards, being parallel to the anterior cardinal tooth. In *C. northcrofti* the lunule remains convex in the adult and so the hinge is not so crowded. Right valve with a large triangular anterior cardinal in front of which is a wide triangular space separating it from the wide lunular margin; posterior cardinal very low. Left valve with a strong, triangular anterior cardinal sloping well forward and adjacent to the lunular margin.

Height 10 mm.; length 15.5 mm.; thickness (1 valve) 6 mm.

Localities: Flower-pot; Whenuataru Peninsula.

Genus *VENERICARDIA* Lamarek, 1801.

Type: *Venus imbricata* Gmelin.

*Venericardia beata* n. sp. (Figs. 48, 50.)

Shell fairly large, suborbicular, plump, beaks at anterior third, high and prominent; posterior dorsal margin arched, descending to the truncated posterior end; anterior end narrower. Lunule cordate, somewhat depressed. Sculpture of 26 to 28 (rarely 22 to 25) strong, rounded radial ribs, with deep interstices which in youth are wider than ribs, but later narrower; posterior 8 ribs narrow and not so high as the others, the ribs bear closely placed, strong, transverse nodules which become sealy or spinous on posterior part of disc. Hinge of right valve with anterior cardinal tooth coalescing with lunule; median cardinal very broadly triangular; posterior obsolete, united with nymph. Left valve with strong anterior cardinal sloping forward almost parallel with lunule; posterior cardinal strong and high. Valve-margins crenate.

Height 35 mm.; length 37 mm.; thickness (1 valve) 12 mm.

Localities: Flower-pot Harbour, Pitt Island; Whenuataru Peninsula, Pitt Island.

Remarks: Strongly resembles *V. purpurata* (Desh.), but generally has more ribs, separated by wider interstices. The left anterior cardinal slopes forward not backward so that the right median is extremely broad.

*Venericardia martini* n. sp. (Figs. 52, 53.)

Shell large, strong, suboval, moderately inflated, beaks prominent, about anterior third, anterior end short, regularly rounded, dorsal margin curved, posterior end truncated in youth, becoming narrowly rounded with age. Surface with 25 ribs, the posterior 7 rather narrow and low, remainder broad, well-raised convex ribs with narrow interstices; the ribs are regularly but weakly transversely tubercular, but in many specimens this is not seen because of the strong growth-lines which intersect the ribs and make them rugose. Lunule very small, sunken, cordate. Hinge of moderate strength, lower margin sinuous, right valve with anterior cardinal coalescing with lunule; posterior triangular, very strong; ligamental nymph deep. Left valve with a very strong anterior and a long strong curved posterior cardinal; nymph weaker than in right valve; sides of teeth and lower side of right nymph strongly striated. Valve-margins broadly crenate.

Height 50 mm.; length 54 mm.; thickness (1 valve) 17 mm.

Locality: Titirangi.

**Venericardia nuntia** n. sp. (Figs. 45, 47.)

Shell somewhat small, inflated, strong; beaks about anterior fourth, prominent, strongly inclined forward; anterior end narrowly rounded, dorsal margin straight, posterior end broadly truncated. Surface with 25 narrow, high, radial ribs, the 9 on the posterior area strongly dentate and close together, the rest with almost smooth crests, separated by much broader concave interspaces. Lunule cordate, deeply sunken. Hinge strong; right valve with fairly strong anterior cardinal coalescing with lunule, and strong forward curving posterior cardinal. Valve-margins crenate.

Height 13 mm.; length 14 mm.; thickness (1 valve) 5.5 mm.

Locality: Waikaripi below Wireless Station, Waitangi.

This species has a hinge similar to that of *V. beata* but the ribs are narrower, smooth, and separated by wide concave interspaces.

Genus **CONDYLOCARDIA** Bernard, 1896.

Type: *C. sanctipauli* Bernard.

**Condylocardia torquata** n. sp. (Figs. 61, 63.)

Shell minute, ovate, strong. Lunule rather deeply concave; escutcheon long and narrow, well defined. Prodissoconch smooth, well marked off from rest of shell by projecting, smooth collar. Sculpture of flattened, smooth, concentric ridges, separated by much narrower interspaces. Hinge of right valve with large ligament pit, a central, triangular part of which is raised; behind the pit is strong narrowly triangular cardinal tooth, separated from posterior margin by deep, narrow gap. There are no other teeth either cardinal or lateral, in this valve at least, but hinge-plate extends full length of both lunule and escutcheon and so makes anterior and posterior margins stand up prominently. Valve-margins smooth.

Height 1.5 mm.; length 1.8 mm.; inflation (1 valve) .5 mm.

Locality: Titirangi.

Only a single right valve was found. The absence of an anterior cardinal may be of generic importance, but more material is required to show whether this is a constant feature or the result of an accident.

Genus **CHAMA** Linné, 1758.

Type: *Chama lazarus* L.

**Chama pittensis** n. sp. (Figs. 49, 51.)

Shell of moderate size, strong, outline subcircular, left valve with a large area of attachment, umbo prominent, strongly prosogyrate, sculpture of well and regularly-spaced concentric lamellae, which are rather short and irregularly undulating, with smooth interspaces, thus producing a gradate shell surface, hinge of left valve with strong triangular cardinal tooth directly below umbo and bounded above by deep wide groove, ligamental nymph short, sunken, extending further back than cardinal tooth.

Height 30 mm.; length 27 mm.; thickness (1 valve) 18 mm.

Localities: Flower-pot Harbour, Pitt Island; Whenuataru Peninsula.

Remarks: Distinguished from *C. huttoni* Hector by relatively greater inflation, and shorter, more regularly spaced lamellae. In

*C. pittensis* the cardinal tooth is situated much further forward than in *C. huttoni*, and is separated from nymph by a deep depression.

Genus ZEMYSIA Finlay, 1926.

Type: *Lucina zelandica* Gray.

*Zemysia zelandica* (Gray).

1835. *Lucina zelandica* Gray, *Yate N.Z.*, p. 309.

1913. *Diplodonta zelandica* Gray: Suter, *Man. N.Z. Moll.*, p. 917, pl. 63, fig. 10.

Locality: Titirangi, plentiful.

Genus THYASIRA Lamarek, 1818.

Type: *Tellina flexuosa* Montagu.

*Thyasira flexuosa* (Montagu).

1803. *Tellina flexuosa* Montagu, *Test. Brit.*, p. 72.

1913. *Thyasira flexuosa* Montagu: Suter, *Man. N.Z. Moll.*, p. 919, pl. 63, fig. 11.

Locality: Whenuataru Peninsula.

Genus MYLLITELLA Finlay, 1926.

Type: *Myllitella vivens* Finlay.

*Myllitella pinguis* n. sp. (Figs. 68, 69, 70.)

Shell minute, subcircular, slightly oblique, well inflated; umbones fairly prominent. Sculpture of low, curved bevelled ribs 4 per mm. at margin, divaricating from a central smooth area. Left valve with small, entire, slightly oblique cardinal under umbo; and with a strong anterior and a strong posterior lateral lamella. Right valve with one or two small tubercles under umbo and with two anterior and two posterior lateral lamellae, upper one in each case almost blending with shell margin, lower one strong. Muscular impressions about equal. Valve-margins entire.

Height 3.5 mm.; length 3.75 mm.; inflation (1 valve) 1 mm.

Locality: Titirangi (common).

Distinguished from other species of *Myllitella* by its greater inflation and more sloping shoulders. *M. finlayi* (Marwick) is larger and has slightly coarser sculpture (3.5 ribs per mm.) and the Castle-cliff species, has finer sculpture (5 per mm.).

Genus ASCITELLINA nov.

Type: *Ascitellina donaciformis* Marwick.

Shell small, anterior end produced, narrowly rounded; posterior end short and broad. Sculpture of fairly strong concentric ridges. Hinge with two divergent cardinals the posterior one bifid; no laterals. Ligament external, nymphs exposed but narrow, sunk below margin, and descending posteriorly. Pallial line unknown.

*Ascitellina donaciformis* n. sp. (Figs. 59, 60.)

Shell very small, longitudinally oval; beaks behind the middle line, inconspicuous; anterior end long and narrowly rounded, posterior shorter and broader, roundly truncated. Sculpture of fine,

sharp concentric ridges, about 8 per millimeter on the centre of disc, many die out on reaching the posterior area where the remainder become thicker, about 4 or 5 per millimeter. Hinge weak: right valve with a narrowly-triangular, grooved posterior cardinal tooth, and a weak lamellar anterior one; no lateral teeth; ligamental nymph short, sunk below the valve-margin. Pallial line not seen. Valve-margins smooth.

Height 6 mm.; length 10 mm.; thickness (1 valve) 1.4 mm.

Locality: Cliffs below Wireless Station, Waitangi.

The only closely related New Zealand shell is an undescribed species from the Waiarekan tuffs, Lorne. It is of the same size and shape but the concentric ridges are much further apart.

Genus *AMPHIDESMA* Lamarck, 1818.

Type: *A. donacilla* Lamk.

Subgenus *Taria* Adams, 1858.

Type: *Mesodesma latum* Deshayes.

***Amphidesma (Taria) porrectum* n. sp.** (Figs. 62, 64, 65.)

Shell large, much produced in front, beaks at posterior third and fourth. Posterior end truncated, bounded by a rounded ridge running from umbo to ventral end of posterior margin; some specimens with a very weak central ridge traversing the area. Surface almost smooth, traces of rounded concentric folds, growth lines well marked distally. Hinge closely resembling that of *A. subtriangulatum* Woods, but the resilifer is relatively larger and more diverging from the posterior lateral teeth. Pallial sinus moderate. Posterior muscular impression broad.

Height 57 mm.; length 93 mm.; thickness (1 valve) 14 mm.

Locality: Titirangi.

Although there is some variation in shape this shell can be readily distinguished from *A. subtriangulatum* by the greatly elongated anterior end, and the generally strongly convex posterior end, also the pallial sinus is deeper and the posterior muscle scar somewhat larger. Some specimens have almost the same outline as *A. ventricosum* Gray, but they do not have such a strong ridge on the posterior area and the pallial sinus is shallower.

Genus *LEPTOMYA* A. Adams, 1864.

Type: *L. cochlearis* Hinds.

***Leptomya concentrica* n. sp.** (Fig. 84.)

Shell subtrigonal; beaks central, very prominent; posterior end narrow, rather elevated. Sculpture of extremely fine, well spaced, low concentric lamellae, no radials.

Height 14 mm.; length 16.5 mm.; inflation (1 valve) 4 mm.

Locality: Whenuataru Peninsula, Pitt Island.

This species is represented by four closed individuals, mostly decorticated, so no full description can be given. Sufficient of the test remains to show that there was no radial ornamentation, and the outline is quite different from that of *L. retiararia* (Hutton) or *L. simplex* Marwick in that the beaks are narrower and higher and the posterior end is much higher.

Genus *MACTRA* Linné, 1758.Type: *M. stultorum* Linné.*Mactra rudis* Hutton.1873. *Macra rudis* Hutton, *Cat. Tert. Moll.*, p. 19.1893. *Standella rudis* Hutton, *Macleay Memm.* vol. p. 77, pl. 8, figs. 83 a, b.1913. *Macra rudis* Hutton: Suter, *Man. N.Z. Moll.*, p. 967.

Locality: Titirangi

A single right valve was found.

Genus *SCALPOMACTRA* Finlay, 1926.Type: *Mactra scalpellum* Reeve.*Scalpomactra scalpellum* Reeve.1854. *Mactra scalpellum* Reeve, *Conch. Ic.* vol. 8, pl. 19, fig. 106.1913. *Mactra* (*Coelomactra*) *scalpellum* Reeve: Suter, *Man. N.Z. Moll.*, p. 963, pl. 63, fig. 14.

Locality: Titirangi. Fragments.

Genus *DOSINIA* Scopoli, 1777.Type: *A. africana* Hanley.(1) Subgenus *Phacosoma* Jukes-Browne, 1912.Type: *D. japonica* Reeve.*Dosinia* (*Phacosoma*) *wanganuiensis* Marwick.1927. *Dosinia* (*Phacosoma*) *wanganuiensis* Marwick, *Trans. N.Z. Inst.*, vol. 57, p. 586, figs. 24, 29, 30.

Locality: Titirangi.

(2) Subgenus *Kereia* Marwick, 1927.Type: *D. greyi* Zittel.*Dosinia* (*Kereia*) *chathamensis* n. sp. (Figs. 66, 67, 71.)

Shell circular, moderately inflated, beaks low. Lunule rather small, not impressed, bounded by incised line; escutcheon absent. Sculpture of close, bevelled, low concentric ridges, about 0.8 mm. wide, much narrower on posterior area, where some disappear altogether. Left hinge with long, strong, curved, posterior cardinal soldered to nymph without groove; strong median cardinal deeply and unequally grooved; long narrow, arcuate, entire, anterior cardinal; and low, narrow elongated anterior lateral. Right hinge with broad well-grooved posterior cardinal; triangular, short, grooved median; small, narrow, anterior cardinal; anterior lateral pit shallow with weak laterals, lower side grooved. Pallial sinus obscured but probably long, narrow, ascending. Valve-margins smooth.

Height 29 mm.; length 31.5 mm.; thickness (1 valve) 7.5 mm.; paratype 34 x 36 x 10.

Locality: Whenuataru Peninsula, Chatham Island.

Genus PARADIONE Dall., 1909.

Type: *Cytherea ovalina* Lamarek.

Subgenus *Notocallista* Iredale, 1924.

Type: *Cytherea kingi* Gray.

**Paradione (*Notocallista*) *multistriata* (Sowerby).**

1851. *Cytherea* (*Callista*) *multistriata* Sowerby, *Thes. Conch.* 2, p. 628, pl. 136, fig. 177.

1913. *Macrocallista multistriata* (Sowerby): Suter, *Manual N.Z. Moll.*, p. 982, pl. 62, figs. 3, a.

Three imperfectly preserved specimens, all left valves, are provisionally identified with the New Zealand Recent shell. One specimen is 40.5 mm. long, and is covered with well-marked, fine striae. It is longitudinally elongated and agrees in shape with specimens from Landguard Bluff, Wanganui, but is considerably larger. The other two specimens are relatively shorter, higher and more inflated, with a rather heavy shell. The outer surface is worn almost smooth except for strong growth-stages.

Possibly we have here two different forms which are worth separating from *multistriata*, but the material at hand is insufficient for accurate differentiation.

Locality: Titirangi.

Genus *BASSINARIA* nov.

Type: *Bassinaria macclurigi* Marwick.

Shell large, oval, strong. Lunule double, both parts bounded by linear depression, no escutcheon. Sculpture of irregular concentric growth-ridges, and indications of lamellae distally. Hinge of right valve the same as that of *Bassina*, except that in front of the anterior cardinal is a deep lateral pit. No left valve was found, but evidently it has a strong anterior tubercle. The nymphs are narrow and much more deeply sunken than in *Bassina*. Pallial sinus broadly linguiform, horizontal. Valve-margins weakly crenate.

***Bassinaria macclurigi* n. sp. (Figs. 73, 74.)**

Shell large, strong, oval, well inflated, with broad indistinct ridge bounding each side of narrow posterior area. Lunule double, lanceolate, not deeply sunken, bounded by shallow groove and with another central groove also shallow; escutcheon absent from right valve. Surface with numerous irregular growth-ridges, occasionally rising into short lamellae on posterior and anterior areas, the whole covered with fine, rather irregular concentric lines. Hinge strong; right valve with almost horizontal, grooved, moderately strong posterior cardinal, separated by a wide space from the fairly strong, grooved median cardinal which has parallel sides; anterior cardinal entire, almost parallel to but shorter than median; anterior lateral pit well marked but without laterals, extending as a narrow groove in front of anterior cardinal. Ligamental nymph narrow, deeply sunk, the side of ligamental pit divided longitudinally into two equal parts the lower one well impressed. Pallial sinus broad, linguiform, horizontal. Valve-margin finely crenate.

Height 65 mm.; length 56 mm.; thickness (1 valve) 18 mm.

Locality: Titirangi.

Only a single right valve was found. The cardinal teeth, the pallial sinus, the sculpture, and the lunule all agree well with *Bassina*, but the anterior lateral pit is a new feature and worth systematic recognition. The pit in the right valve is on a groove situated in front of the anterior cardinal, it therefore has had a different origin from that of *Macrocallista*, *Paradione* etc. (Marwick, 1927, p. 598).

Genus TAWERA Marwick, 1927.

Type: *Venus spissa* Quoy and Gaimard.

**Tawera marshalli** Marwick.

1927. *Tawera marshalli* Marwick, *Trans. N.Z. Inst.*, vol. 57, p. 614, figs. 131-3, 135, 136.

The Chatham Island specimens are smaller than the typical *T. marshalli* and are inclined to have a shorter posterior dorsal margin.

Localities: Flower-pot Harbour, Pitt Island; Whenuataru Peninsula, Pitt Island.

**Tawera marthae** n. sp. (Figs. 72, 75, 76.)

Shell relatively large and strong, suboval to subcircular, well inflated. Beaks behind anterior third. Anterior end broadly rounded, posterior end narrower, dorsal margin high. Lunule large, lanceolate, bounded by an incised line; escutcheon slightly flattened, not sunken. Sculpture of bevelled concentric ribs generally 9 or 10 per cm., but sometimes as many as 15; ribs die away on posterior third of shell which is obsoletely concentrically grooved; some specimens show weak radials corresponding to the marginal crenulations; in others the whole surface shows only obsolete concentric sculpture; in a few the strong concentric sculpture persists to posterior dorsal margin. Hinge rather weak except in old individuals; teeth strongly diverging. Right valve with a lamellar anterior cardinal, strong bifid median and somewhat weaker bifid posterior cardinal; nymph narrow fairly well sunk below dorsal margin. Left valve with narrow cardinals, the median bifid. Pallial sinus short, ascending, apex rounded. Valve margin finely crenate.

Height 32 mm.; length 35 mm.; thickness (1 valve) 10 mm.

Locality: Titirangi, plentiful.

Genus PAPHIRUS Finlay, 1926.

Type: *V. largillierti* Philippi.

**Paphirus largillierti** Philippi.

1835. *Venus intermedia* Quoy and Gaimard, *Voy. Astrol.*, vol. 3, p. 526, pl. 84, figs. 9, 10, not of de Serres.

1849. *Venus largillierti* Philippi, *Zeitsch. F. Malak.*, p. 87.

1913. *Paphia intermedia* Q. and G.: Suter, *Man. N.Z. Moll.*, p. 995, pl. 61, figs. 6, a.

Locality: Titirangi, plentiful.

Finlay (1926, p. 471) was not able to give the reference for the first use of *Venus intermedia*. In Bronn's *Index Palaeontologicus* this is credited to M. de Serres, *Géognosie des terrains tertiaires*, 264, 272, t. 6, f. 8: Paris, 1829.

Genus EUMARCIA Iredale, 1924.

Type: *Venus fumigata* Sowerby.

**Eumarcia plana** Marwick. (Figs. 77, 81, 83.)

1927. *Eumarcia plana* Marwick, *Trans. N.Z. Inst.*, vol. 57, p. 627, figs. 207, 210.

Locality: Titirangi.

Many specimens of this fine large shell were collected from the lowest four feet of the shell bed at Titirangi. In New Zealand *E. plana* occurs in the lower part of the Nukumaruan and in the Wai-totaran.

Genus GARI Schumacher, 1817.

Type: *Tellina gari* Linné.

**Gari stangeri** (Gray).

1843. *Psammobia stangeri* Gray, Dieffenbach *N.Z.* p. 253.

1913. *Psammobia stangeri* Gray: Suter, *Man. N.Z. Moll.*, p. 1003, pl. 61, figs. 9, a.

Locality: Titirangi.

Many large specimens of this species can be collected.

Genus NEMOCARDIUM Meek, 1876.

Type: *Cardium semiasperum* Deshayes.

**Nemocardium diversum** n. sp. (Fig. 85.)

Shell subcircular, inflated, beaks prominent; anterior end regularly convex, posterior broadly almost vertically truncated. Sculpture: about 25 closely placed ribs on posterior area, the upper ones somewhat scattered; rest of disc almost smooth, with about 75 ribs indicated only by shallow bounding lines. Valve-margin crenate throughout.

Height 23.5 mm.; length 25 mm.; thickness (1 valve) 10 mm.

Localities: Cliffs below Wireless Station, Waitangi; Whenuataru Peninsula, Pitt Island.

The specimens from the latter place are mostly decorticated, and so their identification is not certain.

Genus CORBULA Lamarck, 1801.

Type: *C. sulcata* Lamk.

**Corbula howesi** n. sp. (Figs. 79, 80, 82.)

Closely allied to *C. zelandica* Q. and G., but differing in the anterior dorsal margin being straighter and more steeply inclined producing a narrowly-rounded anterior end. The shell is more heavily built than the Recent species, but the sculpture is practically the same, there being considerable variations in the strength of the concentric ridges. The hinge-plate is much stronger in *C. howesi*, and in the right valve the conical tooth is larger but does not project below the hinge-plate as in *C. zelandica*. In front of the tooth in *C. zelandica* the hinge-plate narrows and almost disappears, but in *C. howesi* it is quite wide and continues round towards the anterior adductor. The tooth of *C. zelandica* is generally well inclined but that of *C. howesi* is more vertical. There are corresponding differences between the left valves. Viewed from above the notch for the

reception of the cardinal tooth is narrower in *C. howesi* and the denticle behind the ligamental area is not so distant.

Height 8.5 mm.; length 14 mm.

Localities: Flower-pot; Whenuataru Peninsula.

**Corbula tophina** n. sp. (Fig. 78.)

Shell small, moderately inflated, valves slightly unequal; beaks broad, about anterior third; anterior end narrowly convex; posterior end broadly, obliquely truncated, an angular ridge extends from the umbo to bluntly pointed lower extremity of posterior margin; posterior area concave. Sculpture of weak, rounded, concentric ridges with linear interstices, four or even five per mm. Hinge of right valve with strong conical cardinal tooth immediately below umbo, and very large ligamental gap behind it.

Height 6.75 mm.; length 9 mm.; thickness (right valve) 3 mm.

Locality: Cliffs below Wireless Station, Waitangi.

Remarks: Not closely related to any New Zealand species.

Genus BARNEA Risso, 1826.

Type: *B. spinosa* Risso.

**Barnea similis** (Gray).

1835. *Pholas similis* Gray, *Yate N.Z.*, p. 309.

1913. *Barnea similis* Gray: Suter, *Man. N.Z. Moll.*, p. 1017, pl. 61, figs. 11, a.

Locality: Titirangi, fragment only.

b. CLASS GASTEROPODA.

Genus ATALACMEA Iredale, 1915.

Type: *Patella unguis-almae* Lesson.

**Atalacmea elata** n. sp. (Figs. 97, 98.)

Shell small, conic, fairly strong, apex about anterior eighth. Sculpture of 9 shallow, waved, concentric furrows each still marked by a dark pigment; whole surface crowded by extremely fine radial lines. Muscular impression broad, well marked, with a wide anterior interruption.

Length 4 mm.; breadth 2.8 mm.; height 1.5 mm.

Locality: Titirangi.

Distinguished from the Recent *A. fragilis* (Sowerby) by the greater relative height and the smoother radial ribs.

Genus EMARGINULA Lamarck, 1801.

Type: *Patella fissura* Linné.

**Emarginula pittensis** n. sp. (Fig. 100.)

Shell rather small, ovato conic, elevation variable, apex recurved at posterior fourth. Sculpture of about 27 or 29 primary radial cords with a weaker one appearing in most of the interstices, these are reticulated by spaced concentric cords, the intersections of the two systems being nodular. Valve-margin strongly crenate. Deep, narrow, anterior notch, situated on a slightly-flattened anterior area, and having sides not raised so high as primary ribs.

Height 4 mm.; length 9 mm.; breadth 6 mm.; notch 2 mm. deep.

Locality: Flower-pot Harbour, Pitt Island.

Remarks: The sculpture is much coarser and the shape more oval than that of *E. striatula* Q. and G.

***Emarginula galeriformis* n. sp. (Fig. 104.)**

Shell similar in size and general shape to *E. pittensis*. Sculpture of about 28 strong axial ribs with a weak secondary in only a few of the interspaces. These are crossed by regularly-spaced concentric ribs which make the axials nodulous. The interspaces have a pitted appearance, and give the sculpture a distinctive look. The anterior notch is narrow and is bounded by two strong, sharp ridges much higher than the primary ribs. The anterior end of the shell is regularly convex and not at all flattened.

Height 5.25 mm.; length 8.5 mm.; breadth 6 mm.; notch 2 mm. deep.

Locality: Whenuatara Peninsula.

Genus *TUGALIA* Gray 1843 (em.).

Type: *Tugalia elegans* Gray.

***Tugalia aranea* n. sp. (Fig. 101.)**

Sculpture of about 25 strong primary radials separated by rather wide interspaces in each of which there is generally a weaker secondary radial. These are crossed by high, narrow, well-spaced concentric ridges which render the radials strongly nodulous at points of intersection. The anterior sinus rib divides into three parts. Valve-margin crenate.

Height 7 mm.; length 17 mm.; width 12 mm.

Locality: Flower-pot Harbour, Pitt Island.

Distinguished from *T. elegans* Gray and *T. colvillensis* Finlay by the stronger sculpture and more spaced and fewer ribs.

Finlay (1926, p. 344) advocated the use of Gray's original spelling *Tugali*. There are several misprints in neighbouring pages of Dieffenbach's book, and Gray himself made the correction to *Tugalia* which has been in general use ever since. Correction of misspellings or misprints is in accord with the International Rules, consequently the amended form is used above. Finlay's page references to Dieffenbach incorrectly follow Iredale's of 1915, also the page reference to Iredale has escaped correction. The reference to Dieffenbach should be page 240 not 259, and to Iredale, 1915 B p. 434. These are small matters and practically impossible to avoid in a long paper, but the correction comes aptly under this heading.

Genus *PEROTROCHUS* Fischer, 1885.

Type: *Pleurotomaria quoyana* Fischer and Bernardi.

***Perotrochus allani* n. sp. (Figs. 110, 114.)**

Shell large, conical, imperforate. Spire slightly less than  $1\frac{1}{2}$  times height of aperture, whorls 8 remaining, apex broken; spire-whorls convex, body roundly angled; base slightly convex. Suture lightly impressed. Sculpture: above slit, 5 weak spiral cords with a

still weaker one in interstices; below, about 8 stronger spiral cords with slightly wider interstices. On upper whorls there are no interstitial threads and number of primaries is reduced on these whorls; also, strong oblique axial growth-lines intersect the three upper spirals rendering them moniliform. Base of body-whorl weaker and with closer spirals than the sides, becoming obsolete towards centre, only about outer 16 being visible. Aperture rhomboid; outer lip with narrow slit about middle, making a spiral fasciole ascending shell, above slit, lip slopes obliquely forward to suture, below it is almost vertical. Columella, slightly arcuate below, thickened above and strongly twisted to form deep notch like *Trochus* before joining the parietal wall. Basal margin slightly convex, sinuous when viewed from below.

Height 57 mm.; diameter 66 mm.

Locality: Waikaripi, below Wireless Station, Waitangi.

There is no true umbilicus, but the central part of the base at the insertion of the columella is somewhat sunken.

Genus *MARGARELLA* Thiele.

Type *Margarita violacea* Sowerby.

***Margarella runcinata* n. sp. (Fig. 99.)**

Shell small, turbinate, imperforate, spire two-thirds height of aperture. Whorls five, convex. Protoconch small, broadly tectiform, not definitely limited. Suture slightly appressed. Surface smooth and polished except for a few obsolete spiral threads on base and on some of spire-whorls; also with very fine growth-lines. Aperture circular, entire. Outer lip thin, straight, inclined 45° from vertical. Columella smooth, concave, with a layer of callus extending a short way over slightly concave base.

Height 6 mm.; diameter 7.5 mm.

Locality: Cliffs below Wireless Station, Waitangi.

Distinguished from *M. decepta* (Iredale) by spirals being altogether absent from most of the surface; also by the less expanding and not descending body-whorl. The callus on the inner lip is smooth and flat, not hollowed in the umbilical region, and there is no inclination towards effuseness of the aperture.

Genus *MICRELENCHUS* Finlay, 1926.

Type: *Trochus sanguineus* Gray.

***Micrelenchus rufozona* (A. Adams).**

1853. *Cantharidus rufozona* A. Adams.: *Proc. Zool. Soc.* (1851) p. 170.

1913. *Cantharidus rufozona* A. Ad.: Suter, *Man. N.Z. Moll.*, p. 127, pl. 35, fig. 16.

1926. *Micrelenchus rufozonus* A. Ad.: Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 370.

Locality: Titirangi (common).

Many of the specimens have a broader spire and narrower spiral interspaces than the Recent shells, but others are quite typical.

Genus *ZEMINOLIA* Finlay, 1926.

Type: *Minolia plicatula* Murdoch and Suter.

*Zeminolia lenis* n. sp. (Figs. 102, 103.)

Shell small, conic. Protoconch of less than two smooth whorls with a large bulbous nucleus. Whorls three, convex on spire, body-whorl with rounded periphery and sloping base. Suture bordered below by a fairly wide, flat, or slightly concave *rampe*. Sculpture: penultimate whorl with 8 weak, narrow, spiral ribs; on body-whorl the spirals are obsolete and difficult to count, but there are about 18 altogether, including the base. A moniliform cord bounds the umbilicus, which is widely open. Columella slightly concave.

Height 3 mm.; diameter 3.5 mm.

Locality: Whenuataru Peninsula.

Genus *MAUREA* Oliver, 1926.

Type: *Trochus tigris* Martyn.

*Maurea finlayi* n. sp. (Fig. 105.)

Shell rather small, conical, imperforate. Spire twice as high as aperture. Whorls, five remaining on holotype, but about five including protoconch have been broken from apex of it; body-whorl slightly convex, with a rounded periphery, base slightly convex. Protoconch small, globular, of about one smooth whorl. First conch-whorl with two weak spirals which become strong on second whorl and are crossed by about 16 sharp, spaced axials, forming sharp nodules at intersection of spirals. A weak spiral thread appears on shoulder of third whorl becoming stronger on fourth, a weak thread appearing in the other spiral interspaces; fifth whorl with six spirals of about equal strength, crossed as on previous whorls by sharp axials; sixth whorl with 9 spirals upper three stronger and more widely spaced than lower ones; axials have now ceased to cross all but top two interspaces. On later whorls this condition holds, the spirals on penultimate whorl numbering nine with spiral thread in some interstices. Body-whorl with about fourteen subequal spirals on side and seventeen on base, interstices somewhat narrower and with interstitial thread on those near columella, posterior three spirals are rather strongly beaded, the others weakly so, almost smooth. Aperture rhomboid, outer lip inclined. Columella smooth, twisted.

Height 17 mm.; diameter 13 mm.

Locality: Flower-pot Harbour, Pitt Island.

Finlay's *Venustus* is founded on the same type as *Maurea* but was published several days later.

Genus *ARGALISTA* Iredale, 1915.

Type: *Cyclostrema fluctuata* Hutton.

*Argalista effusa* n. sp. (Fig. 107.)

Shell small, turbinate, umbilicate. Spire low; whorls 4 including protoconch, convex; base flattened. Sculpture of low closely-placed spiral threads, penultimate whorl with 8 increasing to 12; about 26 on the body-whorl including base, where spirals are about half width of the others. Suture slightly impressed. Aperture circular effuse at base of columella, outer lip straight, thin. Columella

concave, thickened below by effusion of aperture. Umbilicus deep, circular.

Height 2.4 mm.; diameter 2.8 mm.

Locality: Flower-pot Harbour, Pitt Island.

**Argalista arta** n. sp. (Fig. 106.)

Shell small, turbate, almost imperforate. Spire low; whorls five including protoconch, convex; base flattened. Sculpture of low spiral threads with linear interstices; penultimate whorl with eight spirals, increasing to 16 just above the aperture because of the rapidly-descending body-whorl, about 26 spirals on the body including base. Suture slightly impressed. Aperture circular, entire; outer lip straight, edge thin, thickening within. Columella concave, calloused, bounded on the outside by a shallow depression in which the umbilicus appears as an almost closed slit.

Height 2.5 mm.; diameter 2.75 mm.

Locality: Flower-pot Harbour, Pitt Island.

Genus **RANGIMATA** nov.

(Named after one of the first Polynesian canoes to reach the Chathams)

Type: *Rangimata pervia* Marwick.

**Rangimata pervia** n. sp. (Figs. 112, 113.)

Shell very small, depressed turbate. Protoconch of two smooth planorbid whorls with large nucleus. Post-embryonic whorls about one and a half, body-whorl rather flattened, depressed near suture. Suture impressed, descending near aperture. Sculpture of from 8-12 close spiral threads on the penultimate whorl; body-whorl with about 45. These spirals are rather sharp and are finely moniliform owing to the numerous growth-lines which are stronger on base. Aperture subcircular, inclined at about 45°, outer lip thin, straight. Inner lip with a large semilunar umbilicus which penetrates nearly to apex and in which earlier whorls can be seen.

Height 2 mm.; diameter 2.6 mm.

Locality: Titirangi, a single specimen.

The umbilicus, being situated well within the aperture, is quite different from the usual type which is formed between the inner margin of the aperture and the base of the shell. Certain of the Turbinidae develop a somewhat similar umbilicus.

Genus **IMPERATOR** Montfort, 1810.

Type: *Trochus heliotropium* Martyn.

**Imperator anthropophagus** n. sp. (Fig. 127.)

Shell similar in size and shape to *I. heliotropium* (Martyn). Sculpture: penultimate whorl with about 6 and body-whorl with about 9 principal moniliform spirals, gradually descending on the whorl and some running out into the spines. In each interstice between the larger spirals is generally a weak, moniliform thread. The whole surface is traversed by oblique growth-lines, which, however, do not form scales on the spirals as in *I. heliotropium*.

Height 40 mm.; diameter (about) 60 mm.

Locality: Flower-pot Harbour, Pitt Island.

Genus *ZETHALIA* Finlay, 1926.

Type: *Umbonium zelandicum* A. Ad.

*Zethalia zelandica* A. Adams.

1854. *Umbonium zelandicum* A. Adams, *Proc. Zool. Soc.* (1853), p. 188.

1913. *Ethalia zelandica* Hombron and Jacquinot: Suter, *Man. N.Z. Moll.*, p. 170, pl. 39, figs. 9, 9a.

Locality: Titirangi, a single fragment.

Genus *ESTEIA* Iredale, 1915.

Type: *Rissoa zosterophila* Webster.

*Esteia insulana* n. sp. (Fig. 115.)

Shell minute, pupoid, spire about three times as high as aperture. Protoconch conoid of two smooth whorls with a large nucleus. Post-embryonic whorls about  $3\frac{1}{2}$ , slightly convex, flattened on upper half of each whorl; body-whorl regularly curved not much inflated. Suture well marked, faintly bordered below. Surface smooth except for some weak, microscopic growth-lines. Aperture ovate, angled above. Outer lip sharp, thickened within, lightly sinuous. Peristome continuous, somewhat thin on parietal wall.

Height 2.5 mm.; diameter 1.1 mm.

Locality: Titirangi.

*Esteia subtilicosta* n. sp. (Fig. 116.)

Shell minute, subulate spire about three times as high as aperture. Protoconch conoid, of one and a half smooth whorls with a large nucleus. Post-embryonic whorls slightly over 4, flattened, slightly convex below; body-whorl regularly curved, not increasing in diameter until the last quarter turn. Suture well marked. Surface crowded with fine regular, oblique axial threads. Aperture oval. Outer lip sharp, thickened within, lightly sinuous. Peristome continuous, rather thick on inner side.

Height 3.2 mm.; diameter 1.2 mm.

Locality: Titirangi.

Genus *MERELINA* Iredale, 1915.

Type: *Rissoa cheilostoma* Ten.-Woods.

*Merelina avita* n. sp. (Fig. 111.)

Shell minute, turriculate, imperforate. Spire about twice as high as aperture. Whorls six, regularly increasing, biangulate, body-whorl occupying over one half the total height. Sculpture of two strong spiral ridges, dividing the whorl into three equal parts, reticulated by 13 sharp axial ribs, the intersections slightly nodular. Body-whorl with three additional, sharp, spaced spirals not crossed by the axials. Aperture broadly oval, oblique; peristome thick, continuous.

Height 3 mm.; diameter 1.3 mm.

Flower-pot Harbour, Pitt Island.

Remarks: This species is closely related to *M. lyalliana* Suter having the same arrangement of sculpture, but it differs in having a larger body-whorl and more rapidly tapering spire, also in lacking the double peristome.

Genus *Rissoina* d'Orbigny, 1840.

Type: *R. inca* d'Orb.

*Rissoina chathamensis* Hutton.

1873. *Eulima chathamensis* Hutton, *Cat. Mar. Moll. N.Z.*, p. 23.

Locality: Whenuataru Peninsula.

Further specimens may justify separation from *R. chathamensis*, but the single specimen collected shows no important difference from the Recent shell.

Genus *Ataxocerithium* Tate, 1894.

Type: *Cerithium serotinum* Adams.

*Ataxocerithium simplex* n. sp. (Fig. 109.)

Shell small, conic. Spire twice height of aperture, body-whorl sharply angled at periphery, base flat, contracting very quickly to short neck. Suture deep. Sculpture: first post-embryonic whorl with concave well spaced axial ribs, three spiral cords appear on second whorl, the lower two much stronger. These are crossed by strong straight axial ribs the junctions being nodulous. On later whorls the three spirals and the axials are of approximately equal strength so shell has regularly cancellate appearance. Axials number about 16 per whorl, interstices between spirals are narrower than cords. An additional weak spiral appears just below suture on last three whorls, and part of another is exposed in suture, but there are no secondaries in interspaces of primary spiral cords. Just below periphery, and emerging from suture is strong spiral cord and another is on base not far away from it. The upper rib marks termination of axial ribs but both are sinuous. Base and neck bear about six more very weak spirals. Aperture rhomboidal. Columella straight with weak fold bordering short canal which obliquely truncates it.

Height 9.25 mm.; diameter 5.25 mm.

Locality: Titirangi.

This species closely resembles *A. pyramidale* Finlay, but it is slightly larger and has no secondary spirals in the interstices of the three primaries.

Genus *Notosinister* Finlay, 1926.

Type: *Triphora fascelina* Suter.

*Notosinister insertus* n. sp. (Fig. 108.)

Shell small, subulate, sinistral. Protoconch damaged. Post-embryonic whorls five, outlines straight, body-whorl keeled, base rapidly contracting to short canal. Suture deep. Sculpture on first three whorls of two moniliform spirals with narrow interspace which on later whorls becomes wider, interspace occupied by a narrow moniliform thread which towards aperture is almost as large as the original two. On body-whorl are 19 axials which form beads on spirals; base with two strong spirals narrowly separated and not crossed by the axials. Aperture oval, oblique, produced into a short canal obliquely truncating the columella, which is smooth.

Height 3.5 mm.; diameter 1.3 mm.

Locality: Flower-pot Harbour, Pitt Island.

Genus *TURRITELLA* Lamarek, 1799.

Type: *Turbo terebra* Linné.

Subgenus *Spirocolpus* Finlay, 1926.

Type: *Turritella waihaoensis* Marwick.

***Turritella solomoni* n. sp. (Fig. 117.)**

Shell large, strong, broad, apical angle  $25^{\circ}$ ; whorls only slightly more than half as high as broad. Suture deep. Sculpture of two very strong cinguli with a concave interspace. On early whorls both cinguli are rounded and of almost equal strength and there is a strong central spiral; later, the upper one becomes angled and not so strong as lower, and middle one disappears. The whole surface is covered with low, close spiral threads, one not far below suture being stronger than the others. Aperture subquadrate; outer lip with deep sinus, its apex slightly above median thread.

Height (estimated) 55 mm.; diameter 15 mm.

Localities: Whenuataru Peninsula (type); Flower-pot Harbour, Pitt Island.

The two strong cinguli give this shell some resemblance to *T. waihaoensis* Marw. and *T. tophina* Marw., but the apical angle is much wider, the spiral threads are wider where developed, and the apertural sinus is not so deep. The species is dedicated to Mr. T. Solomon "the last of the Morioris."

Genus *ZEGALERUS* Finlay, 1926.

Type: *Calyptraea tenuis* Gray.

***Zegalerus crater* Finlay.**

1885. *Trochita alta* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 329 (not of Conrad).

1893. *Calyptraea alta* Hutton, *Macleay Mem. Vol.*, p. 62, pl. 7, fig. 59.

1906. *Calyptraea alta* Hutton, Suter, *Trans. N.Z. Inst.*, vol. 38, p. 326.

1913. *Calyptraea alta* Hutton, Suter, *Man. N.Z. Moll.*, p. 284, pl. 44, fig. 2.

1926. *Zegalerus crater* Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 392.

Locality: Titirangi (common).

Genus *COCHLIS* Bolten, 1798.

Type: *Cochlis albula* Bolten.

***Cochlis notocenica* (Finlay)**

1924. *Natica notocenica* Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 450, pl. 49, figs. 2a, b, c, d.

Locality: Whenuataru Peninsula, Pitt Island.

A single specimen with a rather lower spire than usual in this species.

**Cochlis** n. sp. cf. *australis* (Hutton).

1878. *Lunatia australis* Hutton, *Journ. d. Conch.*, vol. 26, p. 23.

1913. *Natica australis* Hutton: Suter, *Man. N.Z. Moll.*, p. 289, pl. 15, fig. 16.

1924. *Natica maoria* Finlay, *Proc. Malac. Soc.*, vol. 16, p. 101.

1924. *Natica maoria* Finlay: Marwick, *Trans. N.Z. Inst.*, vol. 55, p. 552, pl. 55, figs. 16, 18.

Locality: Whenuataru Peninsula, Pitt Island.

Two fragmentary specimens not good enough for description. These shells have a large nucleus like that of *C. australis* and the umbilicus has no funicle, thus resembling some forms of that species.

**Cochlis pittensis** n. sp. (Fig. 125.)

Shell of moderate size, globose. Spire four-fifths height of aperture. Whorls 6 including protoconch which has small nucleus. Suture appressed. Surface smooth. Aperture bluntly ovate; outer lip straight, inclined 30° from vertical, slightly retracted to suture. Inner lip with thin callus on parietal wall. Umbilicus completely filled by large semicircular funicle.

Height 17 mm.; diameter 16 mm.

Localities: Flower-pot Harbour, Pitt Island (type); Whenuataru Peninsula.

Remarks: No New Zealand species has the umbilicus completely filled by the funicle, the Recent and Pliocene *C. zelandica* most nearly approaching this condition.

Genus **GLOBISINUM** Marwick, 1924.

Type: *Sigaretus drewi* Murdoch.

**Globisinum mucronatum** n. sp. (Fig. 121.)

Shell globose, spire relatively prominent, about one-fourth height of aperture. Protoconch of about two and a half smooth whorls which stand well above the following whorls. Sculpture of some obsolete, waved lirae, mostly developed near the suture and on the base. Aperture large; outer lip antecurrent to suture. Inner margin sinuous. No umbilicus.

Height 14.5 mm.; diameter 13.5 mm.

Locality: Whenuataru Peninsula, Pitt Island.

Closely related to *G. wollastoni* Finlay (= *undulatum* Hutton) but easily distinguished by the much larger protoconch; also the sculpture is almost absent.

Genus **KOROVINA** Iredale, 1918.

Type: *Vanikoro wallacei* Iredale.

**Korovina accelerans** n. sp. (Fig. 122.)

Shell small and fragile. Spire one-third height of aperture and canal. Protoconch bulbous, smooth of about one and a half turns with a large nucleus. Whorls a little over two, convex on the spire; body-whorl greatly expanded. Suture impressed. Sculpture of sharp oblique axial ribs separated by wider interspaces, about 20 high ones on the penultimate whorl but a great many more finer ones on the

body-whorl, of which only about the first fifth has the coarse sculpture. Aperture semilunar, entire. Outer lip slightly concave, inclined about 45° from vertical. Umbilicus very wide, bounded by a well-defined ridge and with radiating costae which traverse the ridge obliquely but do not continue on to the body.

Height 3.5 mm.; diameter 3.5 mm.

Locality: Whenuataru Peninsula, Pitt Island.

Genus *TRIVIA* Broderip, 1837.

Type: *Cyprea monacha* Da Costa (= *C. europea* Mont.).

**Trivia flora** n. sp. (Figs. 118, 119.)

Shell small, ovate, inflated, dorsum smooth somewhat conoid, spire concealed, showing only a small tubercle; sculpture of transverse sharp ridges with much wider concave interstices, about 21 on the outer lip and 16 on the inner, die out almost as soon as they pass from the front of the shell. Only one rib, the 4th from top on outer lip fails to reach the aperture, while the 8th from below on the inner margin on inner lip does not reach the exterior; aperture narrow, widening slightly below, curved to the left above, outer lip rounded, expanded beyond the sides of the whorl and raised above the apex; columella slightly concave above, deeper below, and expanded on the inner margin.

Height 10 mm.; diameters, left to right, 7.3 mm., front to back 6 mm.

Locality: Flower-pot Harbour, Pitt Island.

Remarks: Resembles *T. zealandica* Kirk from the Pliocene of Hawke's Bay, but is not so attenuated anteriorly, and its dorsum is not so regularly rounded, being bluntly conoid.

Genus *PHALIUM* Link, 1807.

Type: *Cassis glauca* Linné.

Subgenus *Kahua* nov.

(From Kahu the Polynesian discoverer of the Chatham Islands.)

Type: *Phalium skinneri* Marwick.

Shell subglobular, thick, sculpture of strong spiral and axial grooves dividing the surface of the body-whorl on a regularly chequered plan. Outer lip with a strong varix, regularly lirate within. Columella almost straight with six equal cords. Inner lip strongly lirate.

Among the divisions of *Phalium*, *Kahua* is perhaps most nearly related to *Semicassis* Morch, type *Buccinum saburon* Lamk. from which it differs in having strong axial sculpture and much stronger spiral sculpture. Also *Kahua* has many more folds on the columella and on the inner and outer lips; the canal is not so sharply twisted; and the anterior notch is shallower.

**Phalium (Kahua) skinneri** n. sp. (Fig. 132.)

Shell thick and strong; spire less than one-third height of aperture. Protoconch tectiform of about four smooth whorls with small nucleus. Post-embryonic whorls four, slightly convex on spire.

Suture impressed. Sculpture: first whorl with two obsolete cords towards top of whorl; second with an additional thread near suture, all crossed by strong growth lines, on later whorls many additional spirals appear but the three primaries can be traced on body though upper is divided into 4, middle into 2, and lower into 2; interstices with additional threads (top one with 4, one stronger), below the third cingulum are 20 strong, broad spiral cords, with narrower interstices, some of the top ones being double. The spirals are regularly cancelled by strong bevelled ridges. Aperture deeply notched below; fasciole indistinctly spirally striated. Outer lip reflexed and much thickened to form strong varix, dentate within. Inner lip thickened, practically filling umbilicus but with no projecting platform; bearing about 16 waved threads of which 6 are on columella.

Height 41 mm.; diameter 31 mm.

Locality: Whenuataru Peninsula, Pitt Island.

Genus *CIRSOTREMA* Moreh, 1852.

Type: *Scalaria varicosa* Lamk.

*Cirsotrema chathamense* n. sp. (Fig. 120.)

Shell of moderate size, turreted, imperforate, whorls convex, body keeled. Suture deep. Sculpture of 16 rather sharp, strong axials with irregular edges, in interstices and on back of axials are 6 spiral threads with about 4 weaker threads in the wide interspaces, axials weakly crested below suture. Base keeled and with fine spirals in the rib-interstices. The anterior of the shell is broken, but there was apparently a strong basal fasciole.

Height (estimated) 22 mm.; diameter 8.5 mm.

Locality: Momoe-a-toa.

Remarks: This species resembles *C. zelebori* in general appearance, but the spiral sculpture is much finer, *C. lyratum* has a shallower suture and coarser sculpture.

*Cirsotrema parvulum* n. sp. (Fig. 124.)

Shell small turreted, imperforate, whorls strongly convex, body keeled. Suture deep. Sculpture of 22-24 narrow axials with rather wider interstices, in which appear 8 or 10 spiral threads, the axials generally have a spur shortly below the suture, on the line of which proceeds a keel limiting the flat base on which the axials are weaker and spirals absent. Aperture circular, effuse on the columellar side and forming a small fasciole; basal margin straight, angled at junction with columella.

Height (estimated) 10 mm.; diameter 4 mm.

Locality: Momoe-a-toa.

*Cirsotrema propelyratum* n. sp. (Fig. 123.)

Shell strong, imperforate, whorls convex, sutures moderately deep. Sculpture of 12 strong, high, roughly edged varices per whorl, narrower than the interstices and slightly crested below suture. Each whorl has about seven low primary spirals, the upper and lower two even weaker than the others; the interspaces between spirals are broadly concave, so there is no dividing line between spiral and inter-

space. The interspaces have generally four secondary spiral threads, the inner two being stronger than the outer ones which are sometimes absent. The spirals rise up to the top of the axial varices on their posterior side, but on the crest and anterior side the axials are roughly lamellar. The spirals cross these lamellae and are marked by very weak spines. At the line of suture, the body-whorl has a strong keel, and the axials are expanded on crossing it. Aperture subcircular not effuse, but with a wide fasciole on the basal side, anterior outer margin straight, forming the flattened base.

Height (estimated) 35 mm.; diameter 12 mm.

Locality: Bryozoan limestone, Flower-pot.

Closely resembling *C. lyratum* Zittel but distinguished by fewer and much less spiny axials, deeper suture, and much stronger basal keel.

#### Subgenus *Tioria* nov.

Type: *Cirsotrema youngi* Marwick.

#### *Cirsotrema (Tioria) youngi* n. sp. (Fig. 128.)

Shell of moderate size, turreted; whorls convex with a strong shoulder. Suture deep. Sculpture of 24 narrow high erect axial ribs on the body-whorl of type, 21 on penultimate, 18 on penepenultimate. A paratype has 28 on body and 25 on penultimate whorl. The ribs have strong posterior spine, but otherwise, except at keel, are smooth. Between spire and suture rib is concave and as interspaces are narrow the shell appears to have prominent, concave, infrasutural shoulder. The body-whorl has well marked base formed by forward overlapping of axial ribs, a weak bounding keel is present in interstices. Rib-interspaces and back of ribs both on the sides and base are crowded with fine regular spiral threads with linear interstices, becoming extremely fine posteriorly. Basal fasciole strong in youth, bounding a narrow umbilicus which is not present in adult. Aperture circular, entire, effuse posteriorly to form a spine, also diametrically opposite to form the basal fasciole. Basal outer margin is straight, but at its outer end is twisted in a peculiar manner so that the resulting rib is lapped over and flattened.

Height (estimated) 25 mm.; diameter 13 mm.

Diameter of a paratype 16 mm.

Locality: Bryozoan limestone, Tioriori.

This shell has no known close relatives, so the subgenus *Tioria* has been set up for it. *Tioria* is characterized by the peculiarly turned-over basal ribs, by the absence of strong spirals on the body which is almost regularly convex except that the shoulder is greatly emphasised by a strong spine on each rib. A keel is formed by the over folding of the ribs on the base, but neither it nor the shoulder is defined by a cord.

#### Genus ODOSTOMIA Fleming, 1813.

Type: *Turbo plicatus* Montagu.

#### *Odostomia pittensis* n. sp. (Fig. 126.)

Shell small ovato-conic. Protoconch involute. Whorls five, outline straight on spire; body-whorl forming two-thirds total height,

periphery obscurely angled, base convex. Suture deeply impressed, bordered below. Sculpture: only a projecting thread bordering the suture, otherwise there are no spirals to be seen even under a microscope. Somewhat regular growth-stages are plainly marked giving the appearance of obsolete ribbing. Columella with one strong fold behind which is an extremely narrow umbilicus.

Height 6 mm.; diameter 2.5 mm.

Locality: Whenuataru Peninsula.

Probably directly ancestral to *O. stygia* Suter from which it differs in having straight-sided spire whorls, and no spirals on the surface except the sutural border.

Genus AUSTROMITRA Finlay, 1926.

Type: *Columbella rubiginosa* Hutton.

**Austromitra plicifera** n. sp. (Fig. 129.)

Shell small, fusiform; spire gradate. Protoconch slightly bulbous of two smooth relatively large whorls. Post-embryonic whorls four, with well defined almost horizontal shoulder, body whorl contracting rather slowly to the short neck which has no fasciole. Sculpture of 25 to 30 low, rounded axial ribs per whorl, the ribs do not reach across shoulder and on later whorls scarcely as far as anterior suture; traces of obsolete spiral cords visible. Aperture long and rather narrow, contracting gradually above not notched below. Outer lip thin, simple, lightly ascending. Columella straight, with three strong folds.

Height 10 mm.; diameter 5.5 mm.

Locality: Whenuataru Peninsula.

Genus AUSTROSIPHO Cossmann, 1906.

Type: *Fusus roblini* Tenison Woods.

Subgenus *Verconella* Iredale, 1914.

Type: *Fusus dilatatus* Quoy and Gaimard.

**Austrosipho (Verconella) asper** n. sp. (Fig. 131.)

Shell large, fusiform, spire less than aperture and canal. Protoconch of three smooth globose whorls with a rather small nucleus. Post-embryonic whorls with a high, slightly concave, fairly broad shoulder. Sculpture of 10 strong, rounded axial ribs persisting from suture to suture, but slightly weaker on the concave shoulder; axials crossed on upper whorls by five strong close spiral cords on sides and two strong, then five weaker spirals on shoulder, these increase later to seven, three, and six respectively, and the interspaces between strong threads are each filled by one weaker secondary spiral.

Height 140 mm.; diameter 65 mm. (both estimated).

Localities: Flower-pot Harbour, Pitt Island; Whenuataru Peninsula.

The axial sculpture is so much stronger than that of *A. adusta* (Philippi) that the species ought to be easily recognized.

Genus *ELLICEA* Finlay, 1928.

Type: *Siphonalia orbita* Suter.

Subgenus *Pittella* nov.

Type: *Pittella valida* Marwick.

Shell fusiform, thick and strong with concave shoulder. Protoconch tectiform, of two smooth whorls with rather large nucleus. Sculpture of rounded axial ribs crossed by strong, spaced spiral cords. Aperture broadly oval, well channelled above, produced below into a long, oblique scarcely twisted canal not notched at the end. Outer lip thick and lightly sinused at shoulder, thin and crenulated below, lirate within. Inner lip thin above, not concealing spirals which enter aperture, bearing several denticles below and a well marked one above.

*Ellicea valida* differs from *E. orbita* especially in its strong axial ribs and concave shoulder. The aperture is much wider posteriorly, because of the shoulder, and there is a strong, entering, spiral cord on the parietal wall.

***Ellicea (Pittella) valida* n. sp. (Fig. 130.)**

Sculpture of about 14 strong, somewhat narrowly-rounded axial ribs, weak or absent on the shoulder and not advancing far down the body-whorl. These are crossed by strong spiral cords with wider, flat interspaces, 3 on first whorls, 4 to 5 on penultimate, 12 on body and about 8 finer ones anteriorly on neck. An additional spiral traverses the middle of the shoulder, very weak at first but fairly strong on the body. The whole surface is covered with strong, dense growth-lines.

Height 37 mm.; diameter 21 mm.

Locality: Whenuataru Peninsula, Pitt Island.

Genus *COMINELLA* Gray, 1850.

Type: *Buccinum testudineum* Quoy and Gaimard.

Subgenus *Eucominia* Finlay, 1926.

Type: *Buccinum nassoides* Reeve.

***Cominella (Eucominia) bauckei* n. sp. (Fig. 133.)**

Shell strong, spire somewhat higher than aperture. Protoconch large, tectiform, of 3 smooth whorls with small nucleus. Post-embryonic whorls nearly 6, early ones strongly shouldered, but later ones only weakly so. Suture undulating, very little impressed. Sculpture of strong axial ribs with fairly wide interstices, 10 on early whorls increasing to 14 on body of type but becoming obsolete on a paratype. Ribs persist from suture to suture but die out quickly on base, they are crossed by spaced, obsolete threads, 4 or 5 on spire-whorls, too weak to be counted on body. Outer lip thin, smooth. Inner lip fairly thick, forming well defined pad. Fasciole well defined, obscurely spirally striated.

Height 32 mm.; diameter 15 mm.

Locality: Whenuataru Peninsula, Pitt Island.

There is a well-defined fold at the base of the columella in young stages, but in the adult it is concealed by the thick inner lip. *C.*

*bauckei* is directly ancestral to and not far removed from *C. elegantula* Finlay from the Upper Pliocene of Castlecliff.

This species is dedicated to Mr. William Baucke, a former resident of the Chathams, who was much interested in and had a wide knowledge of the geologic structure of the Islands.

***Cominella (Eucominia) ellisoni* n. sp. (Fig. 140.)**

Shell large, fusiform, solid, apex acute, almost or quite equal to aperture in height. Protoconch obtusely tectiform, of about 3 smooth whorls. Post-embryonic whorls six, obliquely angled slightly above middle; body-whorl plump, occupying two-thirds of total height, regularly contracting to the short, strongly-fascioled neck. Suture impressed, undulating. Sculpture: a broad cingulum borders the suture below, and occupies a large part of the sloping, slightly concave shoulder; the angle of this shoulder is formed by another cingulum which together with that bordering the suture is divided into blunt knobs by low broad axials with narrow interspaces, about 16 per whorl. There are broad weak spiral cords, about 6 from shoulder-angle to suture below, and 20 on body, with 3 or 4 fine cords in the wide interstices, these fine cords appear on the shoulder but not the fasciole and are crossed by numerous irregular growth-lines. Aperture oval, channelled above with a short, twisted, widely-open canal obliquely truncating the columella, and very deeply notched. Outer lip thin, slightly sinused at the shoulder and broadly convex below, sometimes weakly crenate, and often with spaced lirae within. Columella slightly concave, obliquely truncated below. Inner lip with a thick callus crossing the fasciole and produced to the anterior of the shell in an acute angle.

Height 60 mm.; diameter 31 mm.

Locality: Titirangi.

Remarks: Related to *C. nassoides* (Reeve), but with much less developed axial sculpture.

Genus ZEATROPHON Finlay, 1926.

Type: *Fusus ambiguus* Philippi.

***Zeatronphon lassus* n. sp. (Fig. 143.)**

Shell small, fusiform, spire about equal to aperture and canal. Whorls six remaining, biangulate, with a sloping slightly convex shoulder; body-whorl somewhat inflated, contracted quickly on base. Sculpture of about 16 sharp axials per whorl, with wide interspaces, some are closed in front but others have a free edge. The axials are crossed by two spiral cords forming a cancellate sculpture, intersections being nodulous. Body-whorl with three additional strong spiral cords on base, and seven weaker ones on neck. Aperture oval, produced below into a long, twisted canal not notched at end but strongly recurved. The neck bears a spiny fasciole caused by periodic changes in this curvature at end of canal.

Height 12.5 mm.; diameter 5.5 mm.

Locality: Whenuataru Peninsula, Pitt Island.

Very like *Z. bonnetti* (Cossmann) but with much weaker sculpture and a sloping shoulder which gives the whorls a convex shape.

***Zeatrophon mutabilis* n. sp.** (Figs. 145, 146, 148.)

Shell large, strong, fusiform. Spire<sup>a</sup> conic about half height of aperture. Whorls about 5, generally convex; body-whorl much inflated occupying five-sixths of total height, base contracting to form a short twisted canal with a raised rounded ridge forming a fasciole. Suture plain. Sculpture generally of obscure broad spiral cords with narrow interstices, about 6 on the penultimate whorl and 20 on the body. This is the general type, but it grades into a shell with strong spirals, two on first whorls the upper marking a strong shoulder, others appear in interstices later, on spire-whorls these are crossed by sharp lamellate axials 12 or 13 per whorl, but there are never axials on the body. Aperture broadly ovate, produced below into an oblique, twisted canal truncating the columella and not notched at base. Outer lip straight, sharp, thickened and often lyrate within, antecurrent to suture, scarcely contracted to canal. Columella slightly concave, obliquely truncated below. Inner lip with thin callus sometimes with narrow chink between it and bounding ridge of fasciole.

Height 39 mm.; diameter 27 mm.

Locality: Titirangi.

This shell is closely related to *Z. ambiguus*; in fact young specimens can sometimes scarcely be distinguished. The canal of adult *Z. mutabilis* is always much shorter, the body-whorls more inflated, the axial sculpture is generally poorly developed.

Genus *ZEMITRELLA* Finlay, 1926.

Type: *Lachesis sulcata* Hutton.

***Zemitrella choava* (Reeve).**

1859. *Columbella choava* Reeve, *Conch. Ic.* 11, pl. 37, fig. 239.

1913. *Mitrella choava* Reeve: Suter, *Man. N.Z. Moll.*, p. 431, pl. 19, fig. 13.

Locality: Titirangi, a single specimen, doubtfully identified.

Genus *WAIHAOIA* Marwick, 1926.

Type: *Waihaoia allani* Marwick.

Subgenus *Pachymelon* Marwick, 1926.

Type: *Waihaoia murdochi* Marwick.

***Waihaoia (Pachymelon) renwicki* n. sp.** (Fig. 147.).

Shell fairly large, thick, biconic. Spire about two-thirds aperture. Protoconch large, smooth, scaphelloid, of three whorls with a bluntly pointed apex. Whorls about five, almost flat-sided on spire, body-whorl regularly inflated; fasciole scarcely interrupting the regular curve of the shell. Sculpture of about 16 low narrow axial ribs with wide, concave interstices, these axials are developed only on spire-whorls, are obsolete on penultimate whorl and absent from body. Aperture with a shallow anterior notch. Outer lip straight, slightly ascending, rounded not expanded. Columella with four strong, well spaced plaits.

Height 66 mm. (est.); diameter 30 mm.

Localities: Whenuataru Peninsula; Flower-pot Harbour.

Distinguished from the New Zealand species of *Pachymelon* by the relatively high spire.

Genus *BARYSPIRA* Fischer, 1883.Type: *Ancillaria australis* Sowerby.***Baryspira* n. sp.**

A small incomplete specimen 11.5 mm. long resembling a young *B. mucronata* (Sowerby). The protoconch projects clear of the apical callus, and the spiral depressed area below the smooth area is relatively wider than in *B. mucronata*.

Locality: Whenuataru Peninsula, Pitt Island.

Genus *MARGINELLA* Lamarek, 1801.Type: *Voluta glabella* Linné.***Marginella coxi* n. sp. (Fig. 134.)**

Shell very small, oval, inflated. Spire low. Suture plainly marked by shallow depression. Spire-whorls slightly convex, body-whorl regularly convex, the base curved right to the anterior end. Surface smooth and polished. Aperture curving over above, bordered below. Outer lip thickened, but not ascending above penultimate whorl, practically smooth within, the merest traces of denticulation seen under a good lens and in favourable light. Columella with 4 strong plaits, the lower two stronger than the upper ones.

Height 4.5 mm.; diameter 3.2 mm.

Locality: Whenuataru Peninsula, Pitt Island.

Close to *M. harrisi* Cossman from the Lower Miocene of Awamoa but differing in its greater convexity. *M. harrisi* is relatively more produced anteriorly so that there is a flattening of the body whorl. Although the greater part of the unique type is decorticated, fragments of the surface show a better defined suture than *M. harrisi*.

***Marginella floralis* n. sp. (Fig. 135.)**

Shell small, volutiform, solid. Surface smooth. Spire conical; protoconch obtuse; whorls about 4, convex on spire, body-whorl with a sloping broadly-rounded shoulder slightly convex below. Aperture wider below not notched anteriorly. Outer lip thickened only slightly ascending on to penultimate whorl, smooth within. Columella caloused, with four strong plaits the posterior one almost transverse, the rest oblique.

Height 7.5 mm.; diameter 5 mm.

Locality: Flower-pot Harbour, Pitt Island.

Genus *ZEMACIES* Finlay, 1926.Type: *Zemacies elatior* Finlay.***Zemacies prendrevillei* n. sp. (Fig. 141.)**

Shell large, narrowly fusiform, strong. Suture with broad low border below. Sculpture of about 20 short oblique costae developed only on the rounded shoulder-angle; whole surface covered by fine, close spiral lines. Aperture long, sides subparallel, no anterior notch. Outer lip thin, with a deep, narrowly-rounded sinus its apex about middle of shoulder; below shoulder lip is strongly convex but contracts again to the widely-open canal. Inner lip smooth with a moderate callus.

Height (calculated) 95 mm.; diameter 27 mm.

Locality: Tuffs, Flower-pot Harbour, Pitt Island.

Shells belonging to *Zemacies* occur in New Zealand from the Hamptden beds (*Surcula marginalis* Marshall) as high as the Mokau beds, i.e., from Eocene to Miocene.

Genus MITRITHARA Hedley, 1922.

Type: *Columbella alba* Petterd.

*Mittrithara granum* n. sp. (Fig. 138.)

Shell small, biconical; spire conical about two-thirds aperture. Protoconch of two whorls, the nucleus bulbous and the second one increasing in size. Whorls nearly four slightly convex on spire, body-whorl regularly curved. Suture well marked, bordered below. Sculpture of about 20 low axial ribs per whorl with wider interstices. The ribs extend from suture to suture but are obsolete on body-whorl and do not cross base. Spire-whorls with about 6 weak spiral cords, the upper two close together and bordering suture, below is a wide concave space, then a fairly strong cord; between this and lower suture are three very weak threads. Where the upper three spirals cross the ribs they are slightly nodulous. Body-whorl with about 18 additional spiral threads, obsolete on the most expanded part of whorl but become stronger on base; interstices slightly wider. Also an additional thread on shoulder. Aperture not notched below. Outer lip thin with an extremely shallow sinus above. Columella with two strong oblique folds, considerably shorter than outer lip.

Height 8.3 mm.; diameter 4 mm.

Locality: Whenuataru Peninsula.

Genus INQUISITOR Hedley, 1918.

Type: *Pleurotoma sterrha* Watson.

*Inquisitor acutus* n. sp. (Fig. 142.)

Shell small; spire acute, nearly twice as high as aperture. Suture plain. Protoconch of about  $2\frac{1}{2}$  smooth whorls, top one bulbous. Post-embryonic whorls  $6\frac{1}{2}$ , angled below middle on early ones but at middle on later ones; shoulder steeply inclined except in youth. Sculpture of short, curved, axial ribs 14 per whorl, slightly tubercular on shoulder-angle of body, but rather sharply raised on early whorls; no spirals. Aperture angled above, produced below into short, broad canal not notched at base. Outer lip thin with broadly rounded sinus stretching from suture to shoulder-angle. Inner lip thin.

Height 12.5 mm.; diameter 4 mm.

Locality: Whenuataru Peninsula, Pitt Island.

This shell is closely related to *Drillia costifer* Suter which is doubtfully separable from *Mangilia praecophinoides* Suter. The Chatham Island species has an extra whorl to the protoconch, no spirals are to be seen, and the number of whorls is greater.

Genus GURALEUS Hedley, 1918.

Type: *Mangelia picta* Adams and Angus.

**Guraleus lineatus** n. sp. (Fig. 139.)

Shell very small, broadly fusiform, spire equal in height to aperture and canal. Whorls 2 besides protoconch, angled about middle on spire, base gradually contracting to very short canal. Protoconch large, tectiform, of  $3\frac{1}{2}$  whorls, ornamented by 4-5 spiral threads crossed by axials of equal strength. Sculpture consisting of 11 strong-curved axial ribs passing from suture to suture but soon dying out on base, these are crossed by fine very-widely-spaced spiral threads about 5 on spire whorls, 12-15 on body, the interspaces of all except a few on the neck with 4 or 5 microscopic threadlets trellised by equally fine growth-lines; aperture long, sides subparallel, produced into a short not contracted anterior canal not notched at base; outer lip thin, with semicircular notch extending from shoulder-angle to suture, convex below shoulder, columella straight and smooth.

Height 4.5 mm.; diameter 2.5 mm.

Locality: Flower-pot, Pitt Island.

Genus LIRACRAEA Odhner, 1924.

Type: *Clathurella epentroma* Murdoch.

**Liracraea titirangiensis** n. sp. (Fig. 137.)

Shell small, fusiform; spire equal in height to aperture and canal. Whorls five, convex, body fairly rapidly contracting to short straight neck. Protoconch of two whorls with a smooth tilted nucleus, the last whorl with three strong smooth spiral cords with interstices equally wide, sharply marked from the conch-whorls. Surface cancellate, with two strong spiral cords and a weaker one in the interstices, crossed by about 13 spaced axial ribs, body-whorl with five strong spirals with a weaker secondary and two still weaker tertiaries in the interstices, six or seven spirals anterior to these. Aperture pyriform, angled above, produced below into a short widely open canal, truncated at base. Outer lip thin, with a wide shallow notch adjoining suture. Columella smooth, straight.

Height 4.2 mm.; diameter 2 mm.

Locality: Titirangi.

Remarks: Closely related to *L. epentroma* Murdoch. The spirals do not start until after the nucleus of the protoconch and the spire is not so high.

Genus PHENATOMA Finlay, 1924.

Type: *Pleurotoma novae-zelandiae* Reeve.

**Phenatoma decessor** n. sp. (Fig. 144.)

This species is a direct ancestor of *P. novaezelandiae* (Reeve) which it resembles strongly in shape and ornamentation, but differs in having only 8 instead of 10 primary spirals below the shoulder on the body-whorl. The only protoconch observed shows no axial ribs such as appear on the last part of the protoconch of *P. novaezelandiae*, and there is scarcely any development of the secondary threads so

common in the Recent shell. The shoulder has a moniliform spiral thread bordering the suture, another about the middle and a single weak one between. In a *P. novaezelandiae* of the same size this last thread is represented by three separate ones.

Height 17 mm.; diameter 6 mm.

Localities: Whenuataru Peninsula, Pitt Island; Flower-pot Harbour, Pitt Island.

Genus *RETUSA* Brown, 1827.

Type: *Voluta alba* Kanmacher.

*Retusa pressa* n. sp. (Fig. 136.)

Shell minute, subcylindrical, relatively short and wide. Summit concave, with nucleus projecting above level of rim. No sculpture. Columella with a low wide fold.

Height 2.5 mm.; diameter 1.5 mm.

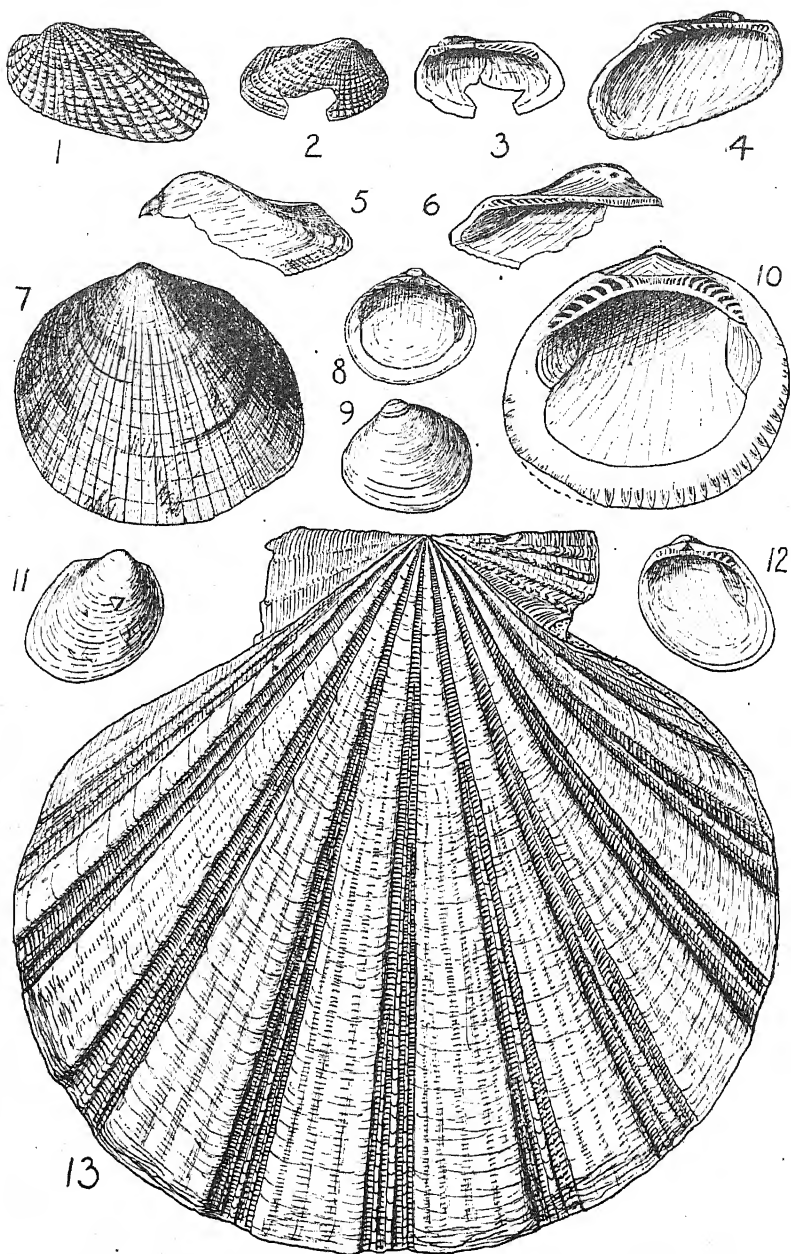
Locality: Whenuataru Peninsula.

Resembling *R. charlottae* (Suter), but easily distinguished by its relatively much greater width.

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FIGS. 1, 4.—*Barbatia* (Acar) *whangaensis* n. sp., holotype x 4, p. 440.

FIGS. 2, 3.—*Barbatia* (*Pugilarca*) *barneaformis* n. subgen., n. sp., holotype x 1, p. 441.

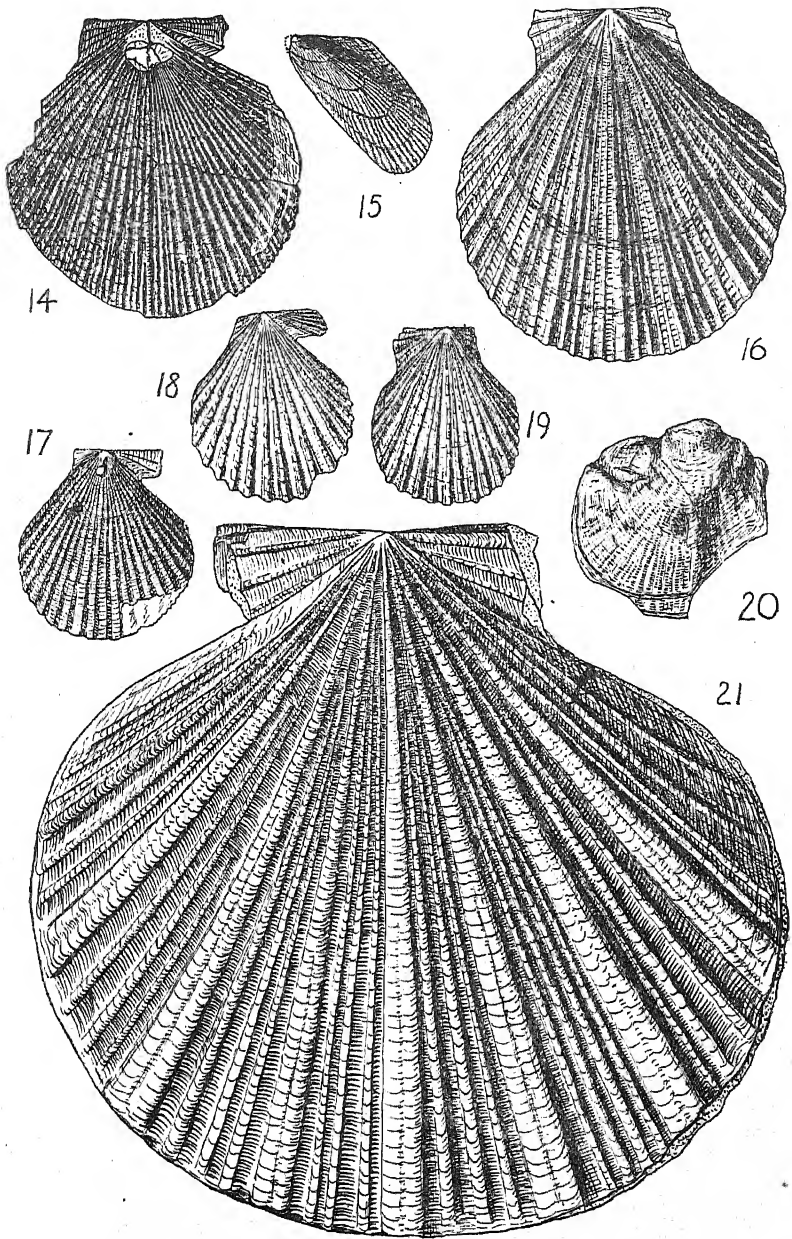
FIGS. 5, 6.—*Arca pittensis* n. sp., holotype x 1, p. 440.

FIGS. 7, 10.—*Glycymeris huntii* n. sp., holotype x 1, p. 442.

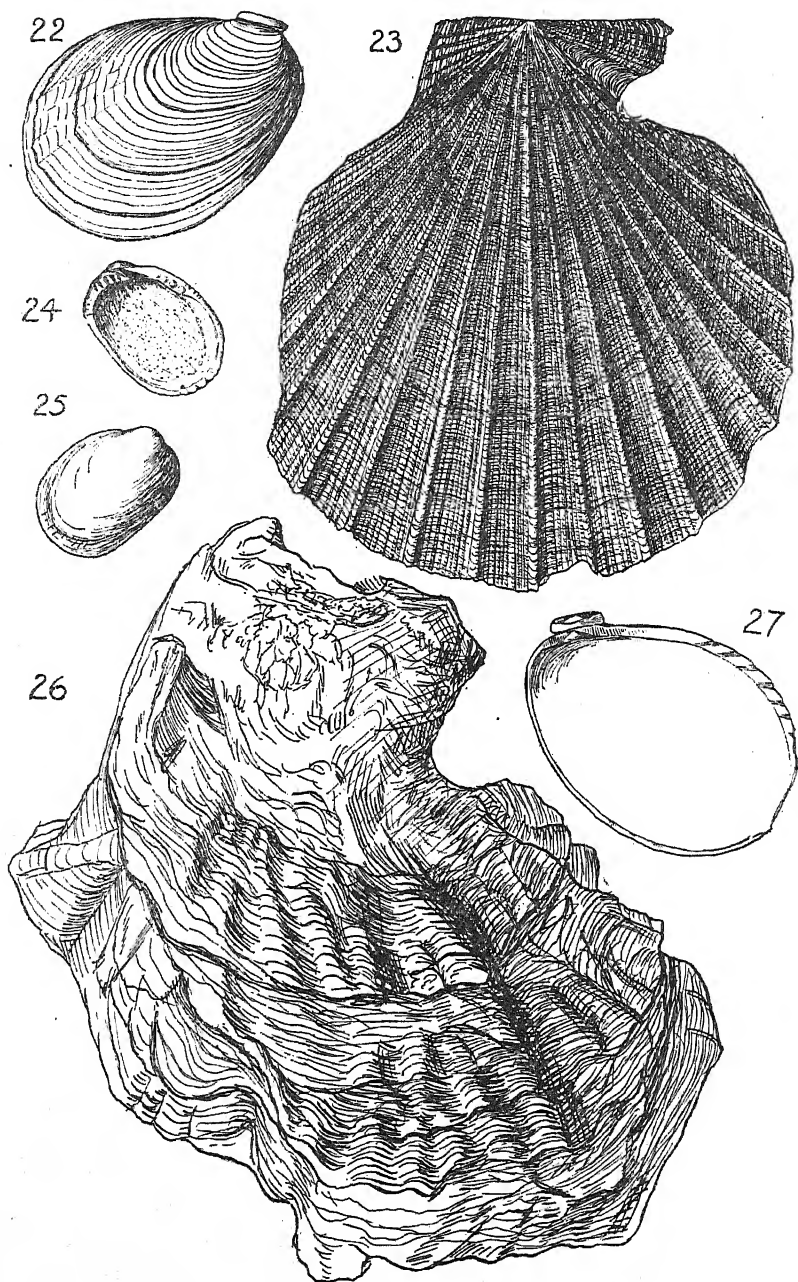
FIGS. 8, 9.—*Perrierina ovata* n. sp., holotype x 10, p. 444.

FIGS. 11, 12.—*Limopsis invalida* n. sp., holotype x 2½, p. 443.

FIG. 13.—*Sectipecten allani* n. gen., n. sp., holotype x 1, p. 459.



- FIG. 14.—*Serripecten tiorioriensis* n. gen., n. sp., holotype x 1, p. 458.  
 FIG. 15.—*Mytilus (Aulacomya) willetsi* n. sp., holotype x 2, p. 444.  
 FIG. 16.—*Sectipecten toaensis* n. gen., n. sp., holotype x 1, p. 459.  
 FIG. 17.—*Chlamys mercuria* n. sp., holotype x 2, p. 457.  
 FIGS. 18, 19.—*Chlamys chathamensis* (Hutton), neotype x 1, p. 456.  
 FIG. 20.—*Monia furcilla* n. sp., holotype x 1½, p. 444.  
 FIG. 21.—*Sectipecten allani* n. sp., holotype x 1, p. 459.



FIGS. 22, 27.—*Philobrya galerita* n. sp., holotype x 25, p. 443.

FIG. 23.—*Chlamys scymouri* n. sp., holotype x 1, p. 457.

FIGS. 24, 25.—*Lissarca fossilis* n. sp., holotype x 5, p. 442.

FIG. 26.—*Ostrea waitangiensis* n. sp., holotype x 1, p. 462.

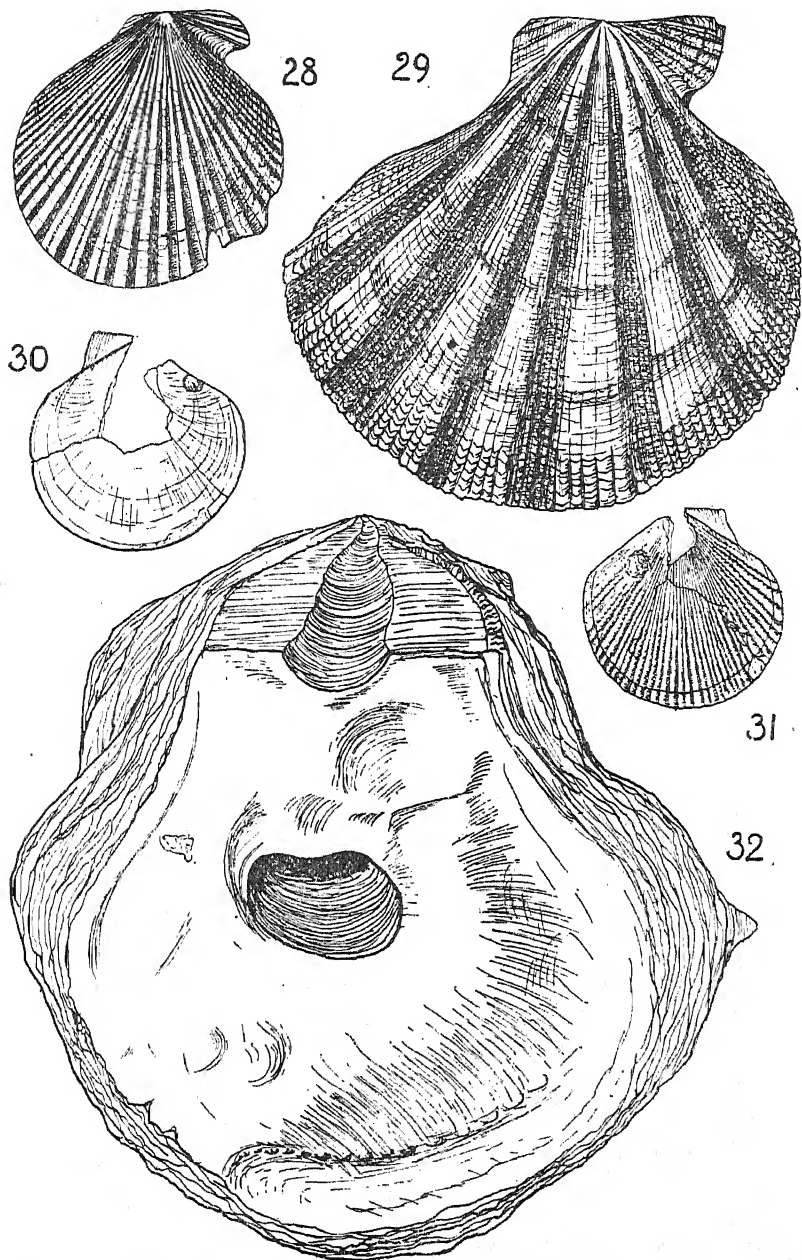


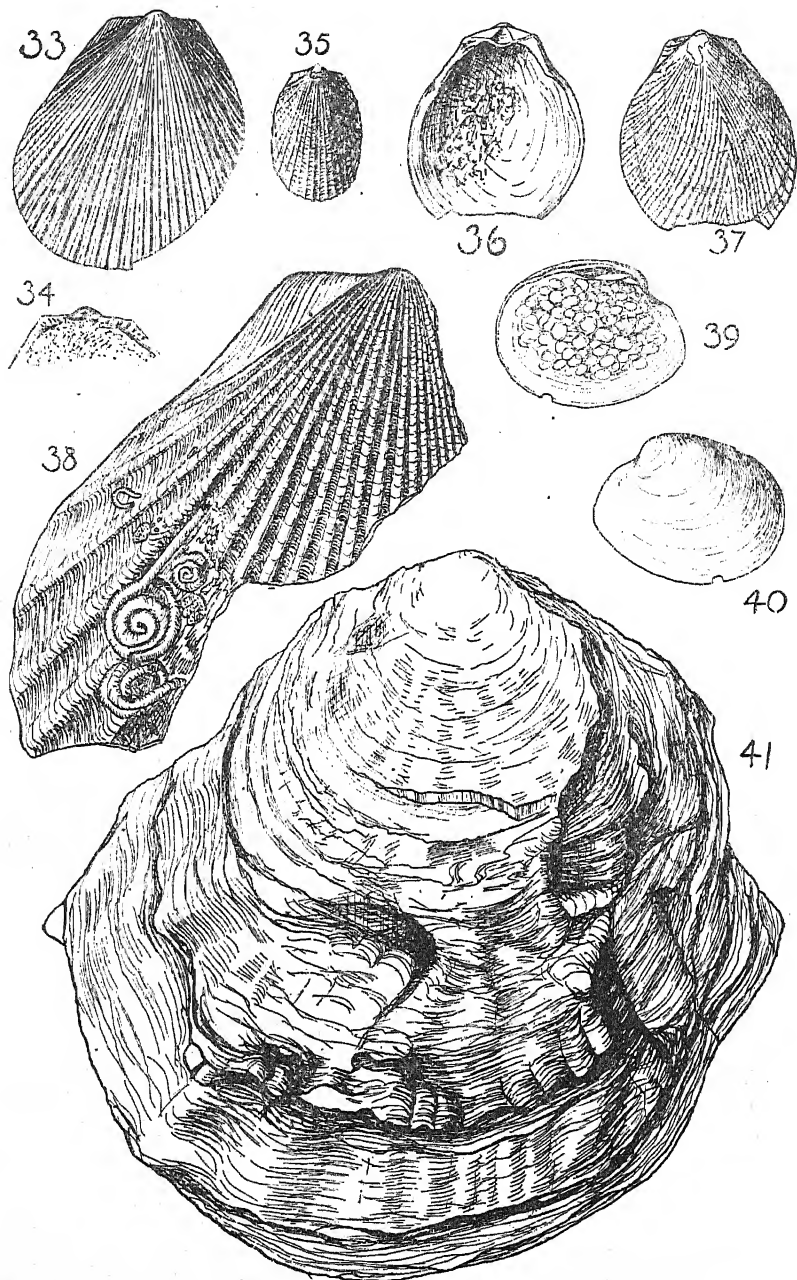
FIG. 28.—*Chlamys titirangiensis* n. sp., holotype x 1, p. 458.

FIG. 29.—*Pallium* (?*Felipes*) *wendyi* (Hutton), topotype x 1, p. 458.

FIG. 30.—*Lentipecten* (*Duplipecten*) *imperfectus* n. subgen., n. sp., holotype, r. valve x 1, p. 460.

FIG. 31.—*Lentipecten imperfectus* n. subgen., n. sp., holotype, l. valve x 1, p. 460.

FIG. 32.—*Ostrea cannoni* n. sp., holotype x 1, p. 462.



FIGS. 33, 34.—*Limea chathamensis* n. sp., holotype x  $2\frac{1}{2}$ , p. 461.

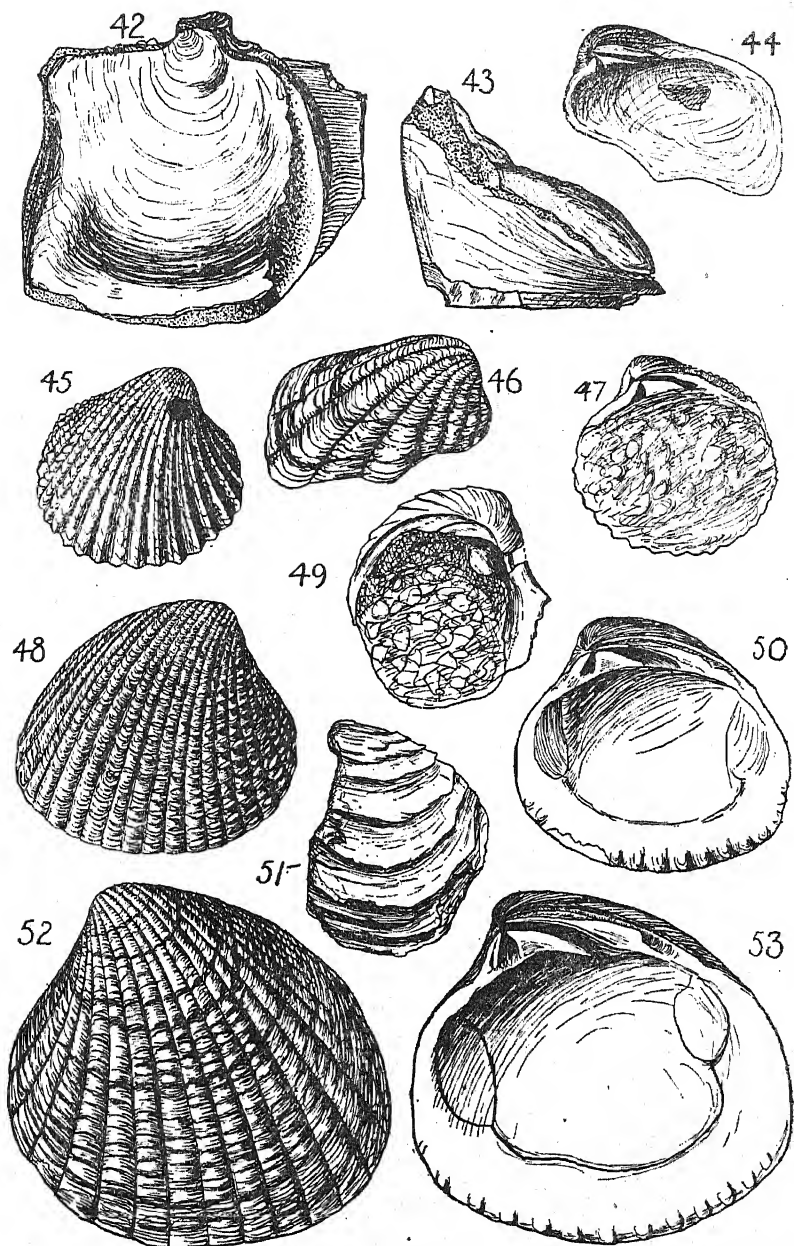
FIG. 35.—*Limatula morioria* n. sp., holotype x 1, p. 461.

FIGS. 36, 37.—*Ctenoides naufragus* n. sp., holotype x 1, p. 461.

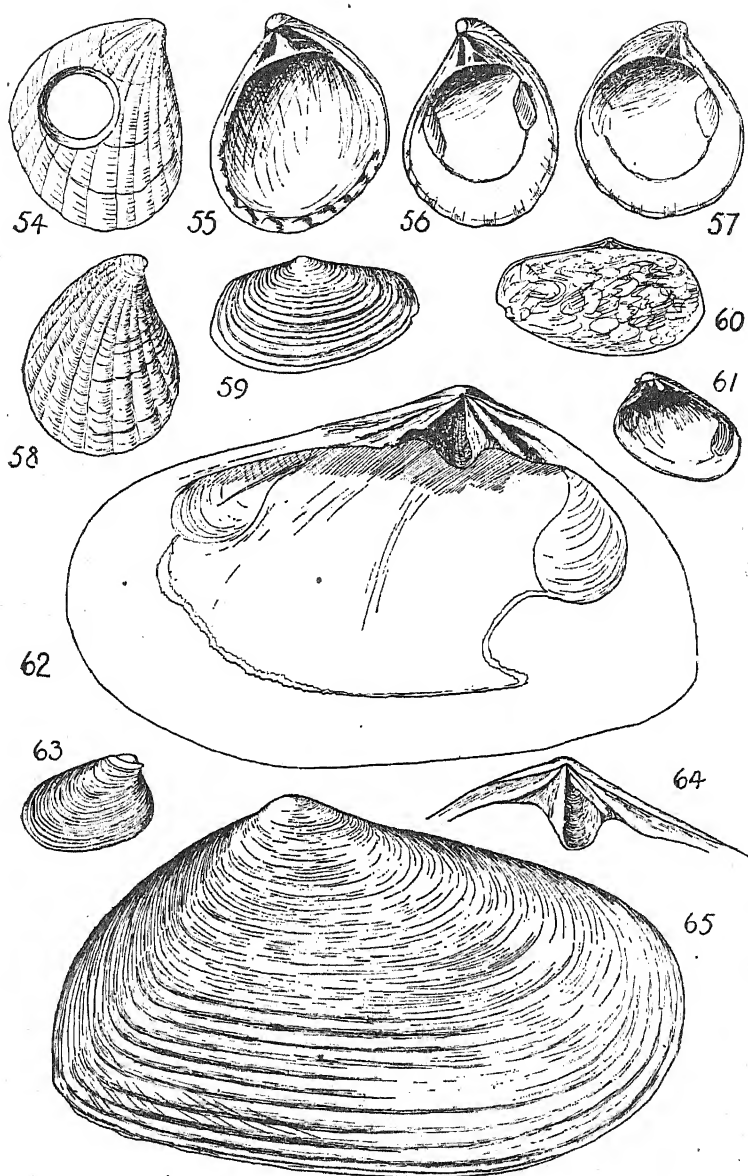
FIG. 38.—*Lima vasis* n. sp., holotype x 1, p. 460.

FIGS. 39, 40.—*Neogaimardia elegantula* n. sp., holotype x 10, p. 463.

FIG. 41.—*Ostrea cannoni* n. sp., holotype x  $\frac{1}{2}$ , p. 462.



FIGS. 42, 43.—*Ostrea arcula* n. sp., holotype x 1, p. 462.  
 FIGS. 44, 46.—*Cardita northcrofti*, n. sp., holotype x 2, p. 464.  
 FIGS. 45, 47.—*Venericardia nuntia* n. sp., holotype x 2, p. 466.  
 FIGS. 48, 50.—*Venericardia beata* n. sp., holotype x 1, p. 465.  
 FIGS. 49, 51.—*Chama pittensis* n. sp., holotype x 1, p. 466.  
 FIGS. 52, 53.—*Venericardia martini* n. sp., holotype x 1, p. 465.



FIGS. 54, 55.—*Cuna antiqua* n. sp., holotype x 9, p. 464.

FIGS. 56, 58.—*Cuna firma* n. sp., holotype x 9, p. 464.

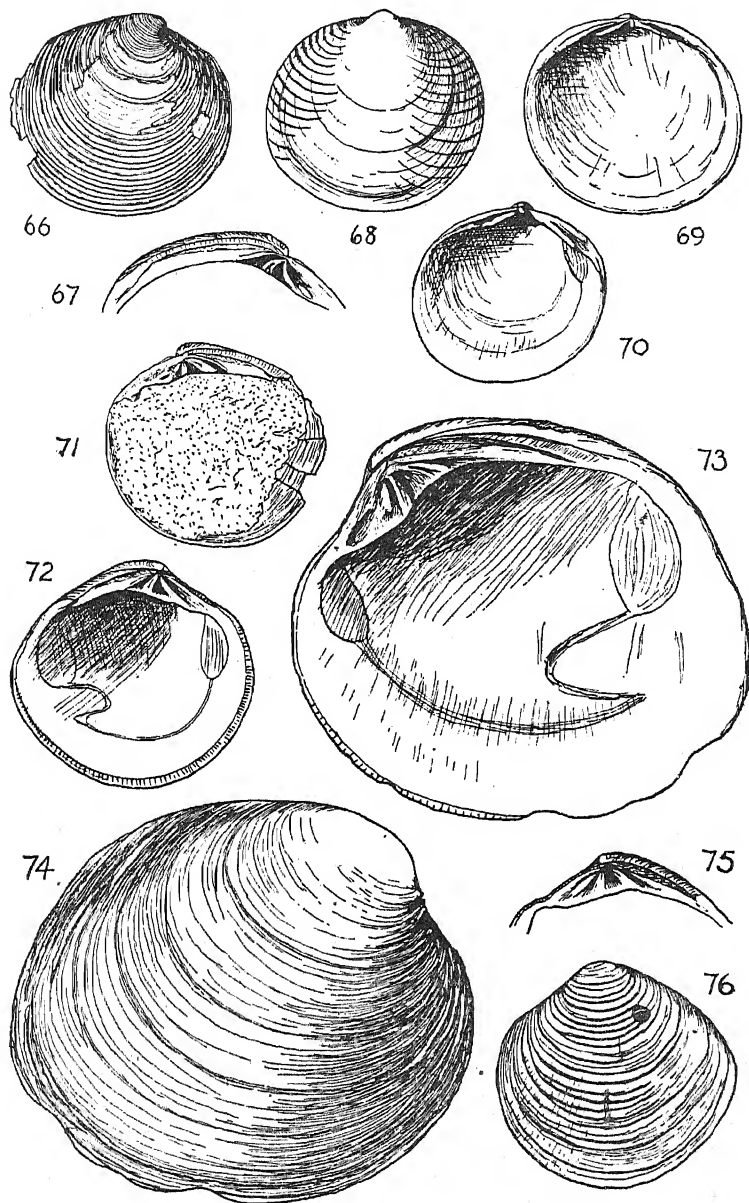
FIG. 57.—*Cuna firma* n. sp., paratype x 9, p. 464.

FIGS. 59, 60.—*Ascitellina donaciformis* n. gen., n. sp., holotype x 3, p. 467.

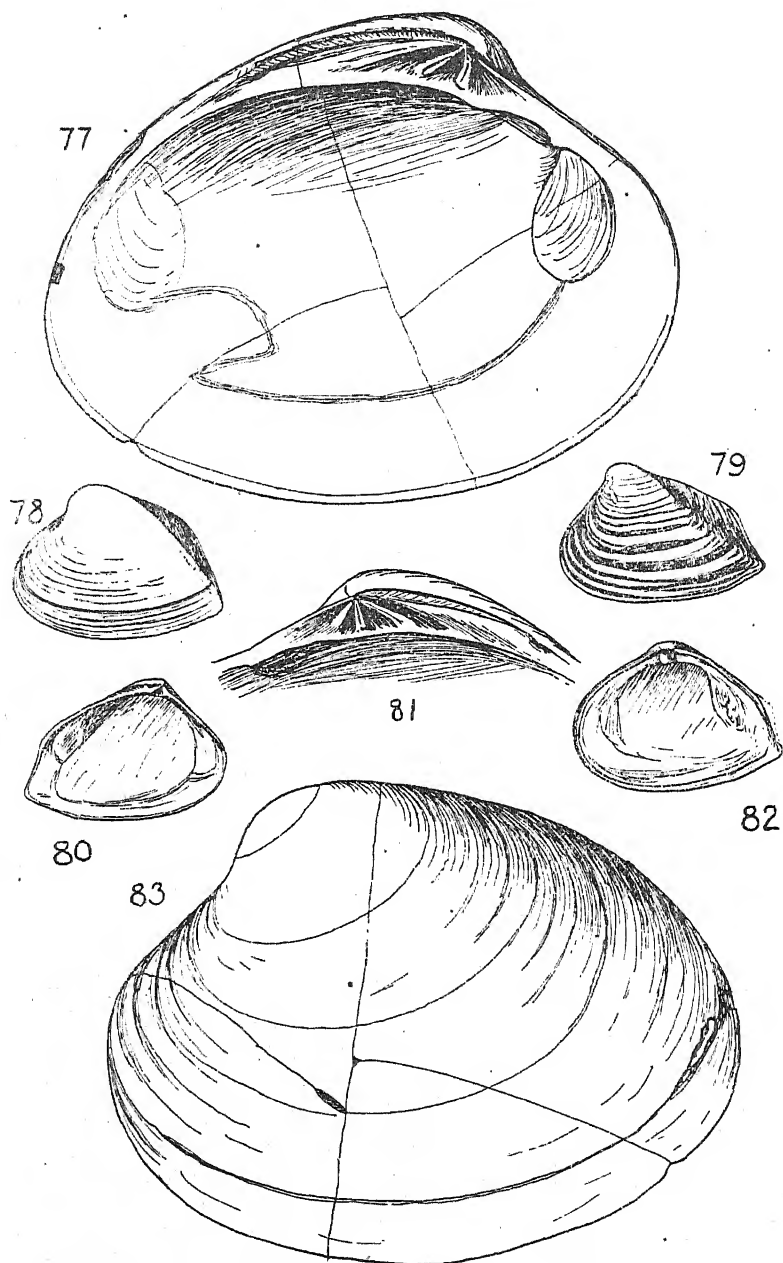
FIGS. 61, 63.—*Condylocardia torquata* n. sp., holotype x 9, p. 466.

FIGS. 62, 65.—*Amphidesma (Taria) porrectum* n. sp., holotype x 0.9, p. 468.

FIG. 64.—*Amphidesma (Taria) porrectum* n. sp., paratype x 0.9, p. 468.



- FIGS. 66, 71.—*Dosinia (Kercia) chathamensis* n. sp., holotype x 1, p. 469.  
 FIG. 67.—*Dosinia (Kercia) chathamensis* n. sp., paratype x 1, p. 469.  
 FIGS. 68, 69.—*Myllitella pinguis* n. sp., holotype x 8, p. 467.  
 FIG. 70.—*Myllitella pinguis* n. sp., paratype x 8, p. 467.  
 FIGS. 72, 76.—*Tawera marthae* n. sp., holotype x 1, p. 471.  
 FIGS. 73, 74.—*Bassinaria macclurgi* n. gen., n. sp., holotype x 1, p. 470.  
 FIG. 75.—*Tawera marthae* n. sp., paratype x 1, p. 471.



Figs. 77, 81, 83.—*Eumarcia plana* Marwick, Titirangi, x 1, p. 472.

FIG. 78.—*Corbula tophina* n. sp., holotype x 3, p. 473.

Figs. 79, 80.—*Corbula howesi* n. sp., holotype x 2, p. 472.

FIG. 82.—*Corbula howesi* n. sp., paratype x 2, p. 472.

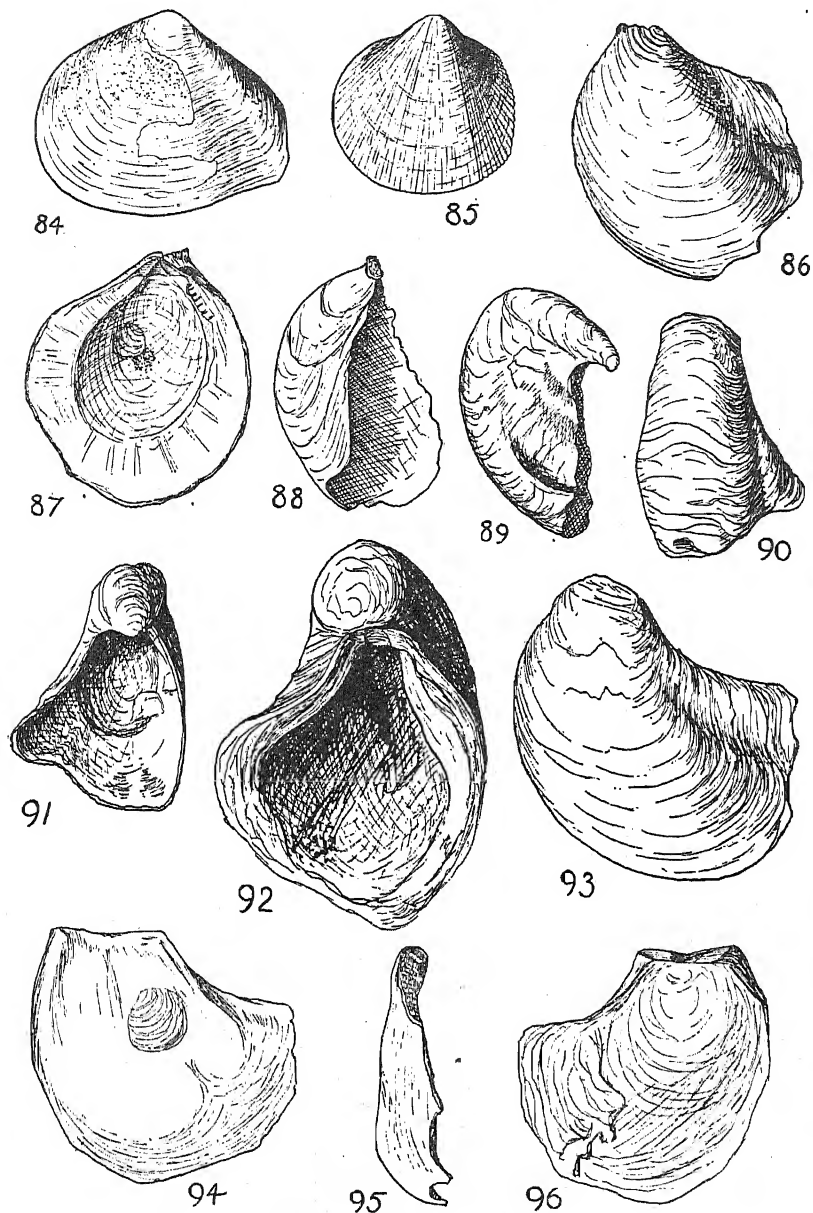


FIG. 84.—*Leptomya concentrica* n. sp., holotype x 2, p. 463.

FIG. 85.—*Nemocardium diversum* n. sp., holotype x 1, p. 472.

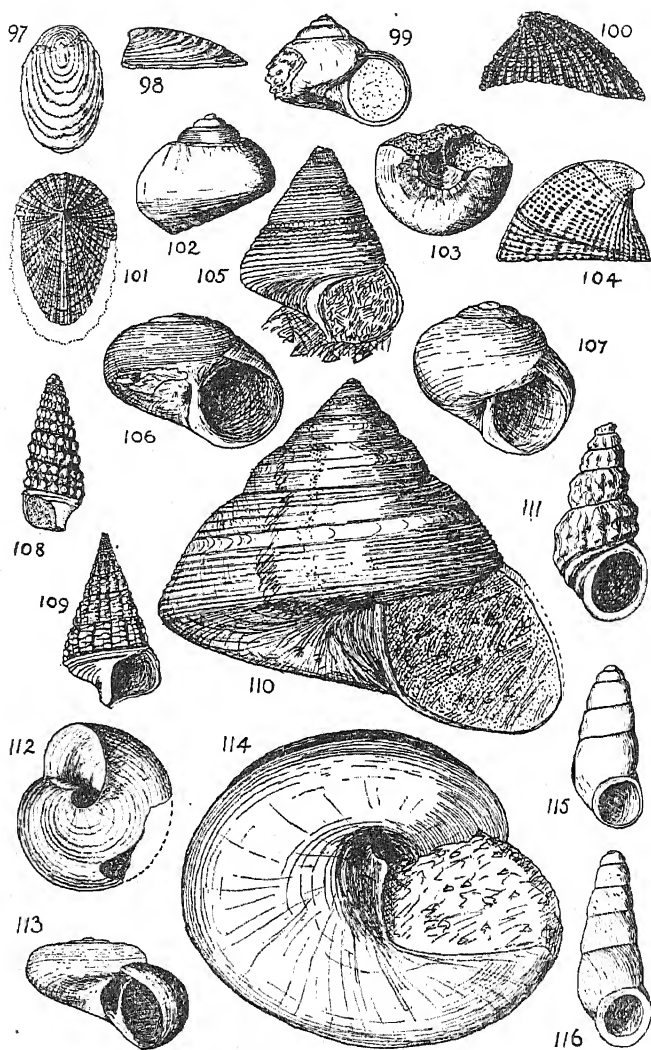
FIGS. 86, 87, 88.—*Notostrea tarda* (Hutton), little curved specimen x 1, p. 462.

FIGS. 89, 90, 91.—*Notostrea tarda* (Hutton), well curved specimen x 1, p. 462.

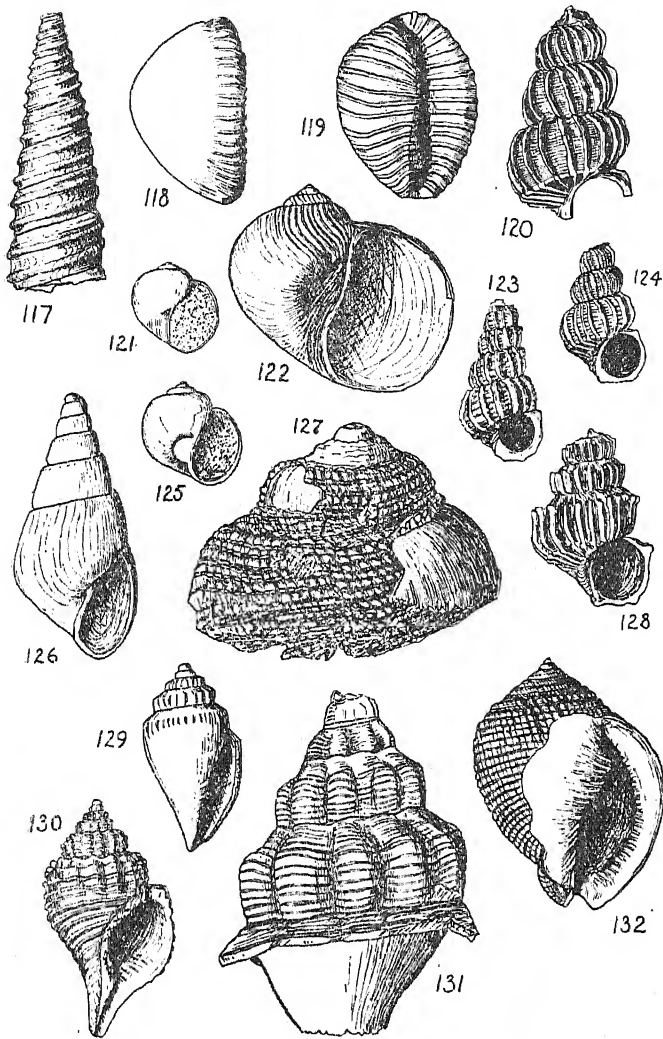
FIG. 92.—*Notostrea tarda* (Hutton), thick specimen x 1.

FIG. 93.—*Notostrea tarda* (Hutton), posteriorly elongated spec. x 1.

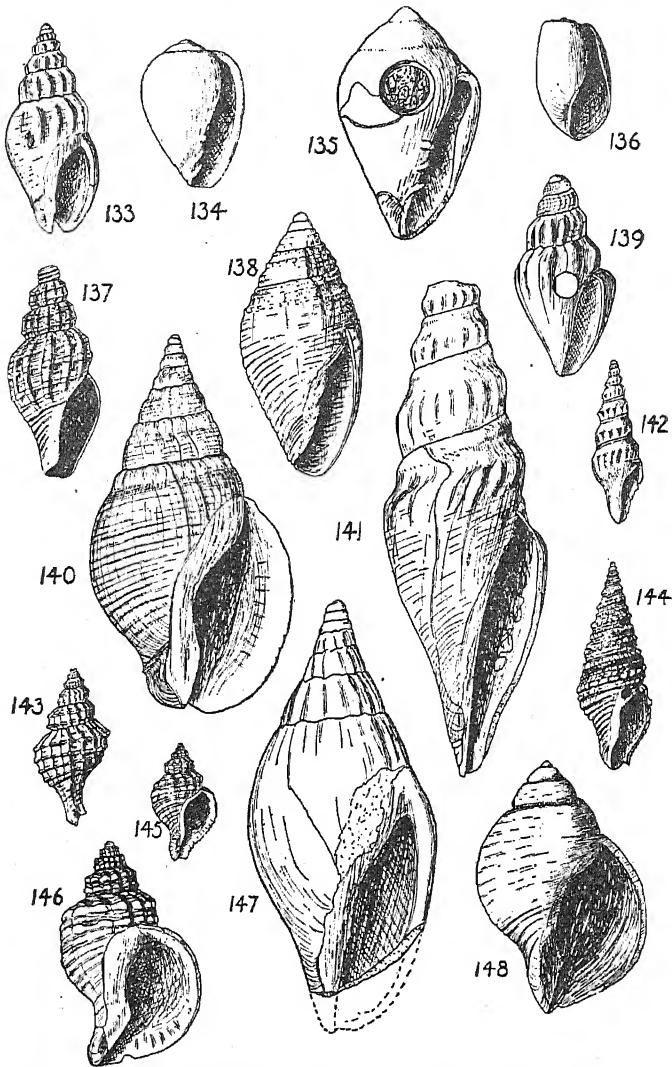
FIGS. 94, 95, 96.—*Notostrea tarda* (Hutton), front, side and back views of right valve of spec. of fig. 93, x 1.



- FIGS. 97, 98.—*Atalacmea elata* n. sp., holotype x 4, p. 473.  
 FIG. 99.—*Margarella runcinata* n. sp., holotype x 2.5, p. 475.  
 FIG. 100.—*Emarginula pittensis* n. sp., holotype x 2.5, p. 473.  
 FIG. 101.—*Tugalia aranea* n. sp., holotype x 1.25, p. 474.  
 FIGS. 102, 103.—*Zeminoia lenis* n. sp., holotype x 5.5, p. 476.  
 FIG. 104.—*Emarginula galeriformis* n. sp., holotype x 2.5, p. 474.  
 FIG. 105.—*Maurea finlayi* n. sp., holotype x 1.75, p. 476.  
 FIG. 106.—*Argalista arta* n. sp., holotype x 8.5, p. 477.  
 FIG. 107.—*Argalista effusa* n. sp., holotype x 8.5, p. 476.  
 FIG. 108.—*Notosinister insertus* n. sp., holotype x 6, p. 479.  
 FIG. 109.—*Ataxocerithium simplex* n. sp., holotype x 2.5, p. 479.  
 FIGS. 110, 114.—*Peretrochus allani* n. sp., holotype x .85, p. 474.  
 FIG. 111.—*Merelina avita* n. sp., holotype x 8.5, p. 478.  
 FIGS. 112, 113.—*Rangimata pervia* n. gen., n. sp., holotype x 8.5, p. 477.  
 FIG. 115.—*Estea insulana* n. sp., holotype x 8.5, p. 478.  
 FIG. 116.—*Estea subtilicosta* n. sp., holotype x 8.5, p. 478.



- FIG. 117.—*Turritella (Spirocolpus) solomoni* n. sp., holotype x .85, p. 480.  
 FIGS. 118, 119.—*Trivia flora* n. sp., holotype x 2.5, p. 482.  
 FIG. 120.—*Cirsotrema chathamense* n. sp., holotype x 2, p. 483.  
 FIG. 121.—*Globisium mucronatum* n. sp., holotype x .85, p. 481.  
 FIG. 122.—*Korovina accelerans* n. sp., holotype x 8.5, p. 481.  
 FIG. 123.—*Cirsotrema propelyratum* n. sp., holotype x .85, p. 483.  
 FIG. 124.—*Cirsotrema parvulum* n. sp., holotype x 2.5, p. 483.  
 FIG. 125.—*Cochlis pittensis* n. sp., holotype x .85, p. 481.  
 FIG. 126.—*Ocostomia pittensis* n. sp., holotype x 6, p. 484.  
 FIG. 127.—*Imperator anthropophagus* n. sp., holotype x .85, p. 477.  
 FIG. 128.—*Cirsotrema (Tioria) youngi* n. subgen., n. sp., holotype x 1.25, p. 484.  
 FIG. 129.—*Austromitra plicifera* n. sp., holotype x 2.5, p. 485.  
 FIG. 130.—*Ellicea (Pittella) valida* n. subgen., n. sp., holotype x .85, p. 486.  
 FIG. 131.—*Austrosipho (Verconella) asper* n. sp., holotype x .85, p. 485.  
 FIG. 132.—*Phalium (Kahua) skinneri* n. subgen., n. sp., holotype x .85, p. 482.



- FIG. 133.—*Cominella* (*Eucominia*) *bauckei* n. sp., holotype x .85, p. 486.  
 FIG. 134.—*Marginella cori* n. sp., holotype x 4.25, p. 489.  
 FIG. 135.—*Marginella floralis* n. sp., holotype x 4.25, p. 489.  
 FIG. 136.—*Retusa pressa* n. sp., holotype x 6.5, p. 492.  
 FIG. 137.—*Liracraea titirangiensis* n. sp., holotype x 6.5, p. 491.  
 FIG. 138.—*Mitrithara granum* n. sp., holotype x 4.25, p. 490.  
 FIG. 139.—*Guralcus lineatus* n. sp., holotype x 6, p. 491.  
 FIG. 140.—*Cominella* (*Eucominia*) *ellisoni* n. sp., holotype x .85, p. 487.  
 FIG. 141.—*Zemacies prendrevillei* n. sp., holotype x .85, p. 489.  
 FIG. 142.—*Inquisitor acutus* n. sp., holotype x 1.6, p. 490.  
 FIG. 143.—*Zeatrophon lassus* n. sp., holotype x 1.6, p. 487.  
 FIG. 144.—*Phenatoma decessor* n. sp., holotype x 1.6, p. 491.  
 FIGS. 145, 146.—*Zeatrophon mutabilis* n. sp., paratypes x .85, p. 488.  
 FIG. 147.—*Waihaeia* (*Pachymelon*) *renwicki* n. sp., holotype x .85, p. 488.  
 FIG. 148.—*Zeatrophon mutabilis* n. sp., holotype x .85, p. 488.

## The Wearing of Beach Gravels.

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Hector and Hutton Medallist, N.Z. Institute.

[Read before the Wellington Philosophical Institute, 11th October, 1927;  
received by Editor, 17th December, 1927; issued separately,  
19th March, 1928.]

IN text books on Geology, the work of Daubree on the abrasion of gravels is still extensively quoted, though his work was done in 1879. In his experiments he generally employed angular fragments of rock, though occasionally rounded pebbles were used. He stated that the principal product of the action was mud, though a notable quantity of sand was also produced:—

“ Le principal produit de l'action mutuelle des fragments de roche solide qui s'usent dans le sein des eaux n'est pas du sable comme on l'a souvent prétendu, mais du limon.

“ Outre le limon, il se produit encore dans la trituration des roches quartzeuses du sable proprement dit . . . . leur diamètre n'atteint pas un quart de millimètre. (*Etudes Synthétiques de Géologie expérimentale*, vol. 1, p. 251 et seq. Daubrée, Paris, 1879.)

Wentworth more recently studied the effect of abrasion on the shape of pebbles and, in particular, estimated the rate at which they became rounded. The latest author, Barrell, has emphasized the fact that practically no sand is produced by this action, but he does not describe any detailed experiments in support of the statement.

The experiments described in this paper were made with natural well-worn shingle from the beach at Napier, New Zealand. This beach is exposed to the prevailing ocean swell from the south-east and the gravel is constantly moved along the beach. The material of the gravel is a hard greywacke rock which is extremely uniform in nature and composition. In each test the gravel was carefully graded in order to find how the materials of different sizes were affected by the treatment. The average resistance of greywacke rock is indicated by its response to the standard tests for roadmaking materials. In these standard tests, its toughness varies from 20 to 30, the French co-efficient 10 to 15 and the hardness 19.

In making his tests Daubrée used a rotating cylinder to produce a sliding movement for the materials employed. There was also provision for a fall of about 6 inches every half revolution. The movement amounted to 160 feet per minute. Wentworth used rotation only, and the pebbles travelled 150 feet per minute. The experiments recorded in this paper were conducted with a Deval Machine. The iron cylinders in which the charges of gravel (always 5,000gm. in weight) were enclosed are 34 cm. long and 20 cm. diameter and inclined at an angle of 30 degrees to a horizontal axis of revolution. They were rotated at an average rate of 38 revolutions per minute,

and with each charge of gravel two litres of fresh water were added. The pebbles had a fall of several inches every half revolution or 76 times per minute, and slid for a distance of about 65 feet every minute. This gives a motion which approximates to one mile per hour. It is thought that this is generally similar to the movement of pebbles on a beach, though on the New Zealand beaches ocean waves reach the strand to the number of 10 to 15 per minute. The movement due to each wave is far greater than that in the Deval Machine, and the pebbles are moved over the floor of the same greywacke material instead of that of an iron cylinder.

The greywacke rock is rather fine grained. The component grains are only occasionally as large as 0.4 mm. in diameter. The average is probably about 0.2 mm. After the pebbles had been treated in the Deval Machine, it was found that the component sand grains of the greywacke were worn on the surface but were seldom knocked out of the parent rock.

Daubrée states that when rounded pebbles of granite were used in his experiments the loss amounted to 0.25 to 1.0% for 15 miles of travel; equivalent to 0.4 to 1.6% of loss for 24 miles of travel.

The greywacke used in the present experiments lost about 1.6% in 24 hours. Daubrée did not grade the materials he used and gives no quantitative statements of his results.

#### ABRASION.

The first tests were made with two typical samples from the Napier beach, each 5000gm. in weight and before treatment they were divided into the following grades:—

2" to 1½"	50.8 to 38.1 mm.
1½" to 1"	38.1 to 25.4 mm.
1" to ¾"	25.4 to 19.0 mm.
¾" to ½"	19.0 to 12.7 mm.
½" to ¼"	12.7 to 6.3 mm.
¼" to ⅛"	6.3 to 3.4 mm.

After the samples had been treated for 24 hours, they were washed, regraded, and the weight of the material of each grade was recorded. This in the case of sample A was repeated 15 times. After the first period the loss was found to be 193.5 gm. This loss consisted of fine grained material which floated off when the gravels were washed. An examination of the floated substance showed that it contained only 0.01% of substance coarser than 0.07 mm. in diameter. When the weights of the different grades of the sample were scrutinized, it was found that one-third of the loss (67 gm.) was derived from the grade of material finer than ¼" (6.3 mm.). Contrary to expectations, no sand was formed. The material graded between one-tenth and one-twentieth of an inch (2.0 to 1.18 mm) weighed only 11.2 gm. In order to test this still further in the grading subsequent to 48 hours, the finer material was separated into the following grades:—

1/8" to 1/10"	3.4 to 2.0 mm.
1/10" to 1/20"	2.0 to 1.18 mm.

*Sample A—Table 1.*

After 168 hours, the weight of material smaller than one-twentieth inch (1.18 mm.) was also estimated. The conditions of the experiment were not extremely exact, for it was difficult to wash the material quite cleanly from the cylinder, and the method of separation of grains by sifting always causes some inaccuracy. It is, however, probable that on the average the results of sifting are fairly accordant. At any rate it was found that even in the small quantities of finely graded material the results were remarkably consistent. The more noticeable points were these:—

The total material finer than  $\frac{1}{4}$  inch (6.3 mm.) was always small. In Sample A the original amount was 8.82%. On treatment this was reduced rather rapidly, and in 144 hours amounted to 7% only. Thereafter the percentage remained practically constant, and this appears to be the percentage of this grade stable or proper to this particular gravel under the condition of movement in the experiment. In this paper it is termed "the equilibrium proportion."

The second point was that the percentage of material finer than one-eighth inch (3.4 mm.) was practically constant at 0.035%, even when the percentage lost varied around 1.5 in 24 hours, the word "loss" always referring to the material finer than 0.07 mm. in diameter. Table 1 shows that this loss is about 75 gm. or 1.6% of the total weight in every 24 hours. The coarser material underwent relatively little change, though the tendency of grade  $\frac{1}{2}$  to  $\frac{1}{4}$  inch (6.3 to 3.4 mm.) was to increase, but the actual amount was no more than an increase from 25.75% to 26.9% after 360 miles of travel. The change that the table shows in the coarsest grade was large, owing to a slight reduction in the size of some of the fragments which allowed them to pass through the holes in the sieve which had previously been too small.

The stability of the proportions of the different grades is remarkable, and suggests that the conditions of movement in the experiments closely approach those that prevail on an actual beach. At the close of the test after 360 hours 21.4% of the weight of the gravel had been lost or converted into material finer than 0.04 mm., yet this considerable amount of loss had not been associated with any but the slightest amount of change in the grading of the gravel apart from the decided loss in the amount of the finest grade from 8.82 to 6.9%.

*Sample B—Table 2.* The gravel used in this sample had somewhat different percentages from those of Sample A in the various grades of the constituents of the gravel. It came, however, from the same beach, and is composed entirely of the same grey-wacke rock. The most noticeable difference is a smaller quantity of  $\frac{1}{4}$  to 1-10th inch (6.4 to 2 mm) which amounted to 170.7 gm. or 3.4% in place of 8.8% in Sample A. There was also a larger quantity of  $\frac{1}{2}$  to  $\frac{1}{4}$  inch (12.7 to 6.33 mm). The test periods employed were 48 hours. There were the same general results. No sand was produced, but the main product of the action was 2% of material finer than 0.04 mm for every 48 hours. There was a striking difference of a special nature, when this sample was compared with

Sample A Table 1. This is seen in the changes of the proportion of the grade  $\frac{1}{4}$  to  $1/10$ th inch (6.4 to 2.0 mm). Originally this weighed 170.7 gm. or 3.41%. The amount and percentage constantly increased and finally after 360 hours of treatment it amounted to 221 gm. or 5.2%, and was still increasing. It is clear that the equilibrium proportion for this constituent of Sample B had not been reached. In Sample A the equilibrium proportion for the  $\frac{1}{4}$  to  $\frac{1}{8}$  inch (6.3 to 3.4 mm) material is approximately 7% of the total weight, and it is probable that the relative coarseness of this sample may require a higher percentage of the finer graded material than in Sample B before the equilibrium proportion is reached. In Sample B also there seems to have been a slight excess of the constituent 1 to  $\frac{3}{8}$  inch, the percentage of which decreased from 18.4 to 16.1 in 384 hours.

*Sample O—Table 4.* In order to test the tendency of a sample of gravel to change its grading under the action of abrasion during the periods employed, experiments were made with a sample consisting of equal quantities of 5 grades between  $1\frac{1}{2}$  inches (38.1 mm) to  $\frac{1}{8}$  inch (3.4 mm). The sample was treated for six periods of 24 hours each and was dried, graded, and weighed after each period. It was found that the quantity and proportion of the grading between  $\frac{1}{4}$  and  $\frac{1}{8}$  inches (6.3 to 3.4 mm) constantly decreased at the rate of 0.5% every 24 hours. The other grades showed no important change during the four periods. Of the fine material produced by the abrasive action on this sample 21.4 gm of the grade  $\frac{1}{4}$  to  $\frac{1}{8}$  inch (6.3 to 3.4 mm) was produced in 24 hours, and after 144 hours' treatment the quantity of this grade amounted to 34.7 gm., or 0.78% of the total in place of 0.44%. The small amount of increase in this constituent in the last three periods of the treatment showed that the amount of this grade had practically reached its equilibrium proportion in 144 hours. The material of one-tenth to one-twentieth inches grade (2 to 1.18 mm) reached its equilibrium proportion (.025%) at the end of the second period of 24 hours. The material between one-twentieth and one-two hundredth inches (1.18 and 0.07 mm), a wide range, attained its minute equilibrium proportion of 0.00092% at the end of 24 hours. The finest material between 0.04 mm and 0.0004 mm amounted to about 90 gm. or 1.9% in each of the 24 hour periods. This experiment emphasises the fact that when a sample is not graded in proportions appropriate to its dominant nature and to the conditions of abrasion, the wearing action at once tends to rectify those incongruities that exist.

*Sample K—Table 5.* In order to test still further the rate of abrasion and the adjustment of the grade of materials to the conditions of movement in the periods of treatment, another type of sample was used. (See Table 5). It consisted of 2500 gm. of gravel  $1\frac{1}{2}$  to 2 inches (38.1 to 50.8 mm) and 2500 gm. of gravel  $\frac{1}{2}$  to  $\frac{1}{4}$  inch (12.7 to 6.3 mm). The loss in this case was very high, especially in the finer material, in which it amounted to nearly 10% in 24 hours. The grading of material between  $\frac{1}{4}$  and  $\frac{1}{8}$  inch (6.3 to 3.4 mm) had clearly made a good start. As in all cases, the material between one-twentieth and one-two hundredths inches

(1.18 to 0.07 mm) was almost negligible while the silt and clay amounted to 234 gms. The result in these respects merely emphasises that obtained from the treatment of Sample A and Sample O. It was very noticeable that the loss of the finer grade  $\frac{1}{2}$  to  $\frac{1}{4}$  inch (12.7 to 6.3 mm) was 15 times as rapid as when material of this grade was used by itself. Sample C, Table 5. In other words, 2500 gm. of this grade lost 234 gm. compared with the loss of 30 gm. from 5000 gm. when this grade was used by itself for the same period. In addition another 181 gm. were reduced to a finer grade than  $\frac{1}{4}$  inch (6.3 mm) which was the finest material at the beginning of the experiment. The loss of the coarser material 2-1 $\frac{1}{2}$  inches, however, was slightly less than when used by itself; for 2500 gm. lost 2.3% in Sample K whereas in Sample F, Table 5, 5000 gm. used by itself lost 6% in 24 hours.

In Sample A it was seen that the amount of fine gravel material, grade  $\frac{1}{4}$  to  $\frac{1}{8}$  inch (6.3 to 3.4 mm), decreased at a rate far more rapid than that of all the grades of coarser gravel. In order to decide whether this variation was an important action, tests were made of a sample of each separate grade. Samples, F, E, G, D, C, H, L, Table 5. The results showed that the gravels of coarser grades abraded far more rapidly than those of finer grade. So far as the experiments went it appears that the amount of abrasion actually varies almost exactly in the same proportion as the diameter of the average pebble of each grade until a small grade  $\frac{1}{4}$  to  $\frac{1}{8}$  inch (6.3 to 3.4 mm) is reached. Using this fine material it was found that the rate of abrasion diminishes far less than the amount equivalent to the reduction in size of the average pebble. When a still smaller size  $\frac{1}{4}$  to 1/10th inch (6.4 to 2.0 mm) is tested it is found that the amount of abrasion actually increases in a decided manner. The probable explanation of this will be given later under the heading "Impact."

In one typical instance an estimation was made of the grade of the materials finer than 0.07 mm. Sample G, Table 5 was employed and the result showed that clay was the most important constituent with particles smaller than 0.002 mm diameter, and fine silt with a diameter between 0.01 and 0.002 mm was also present in large quantities, but there was not much material coarser than this. The smallest particles had a diameter of 0.0004 mm. This result gives a total of 86.48 gm. whereas only 72 gm. were lost from the sample. The difference is ascribed to iron worn from the cylinder and to water absorbed from the air by the fine clay. The proportion of water absorbed or combined by the clay was found to amount to 10%.

The effect of this treatment on the shape of the pebbles was not very pronounced. Actually it was found that the pebbles became distinctly rounder and the flat pebbles from the beach were clearly wearing on their edges. The change of form was not great, but it points to the conclusion that the movement of the pebbles during the experiment involved a greater amount of throw, and a relatively smaller amount of sliding, than under natural conditions on a beach.

The results of these tests on abrasion may be generally summarized as follows:—

- (1) The effect of the wearing of gravel under this imitation of beach conditions follows laws that define the proportion of the different grades of coarseness most precisely, though these cannot be given a quantitative expression without a far more extensive series of experiments.
- (2) Under the conditions employed the rate of the wear of the beach gravel subjected to experiment amounts in 24 hours to a value between 1 and 2% for every 24 miles of movement in the machine.
- (3) Practically no fine or coarse sand is formed by the action, though in the experiments the two samples of gravel A and B were reduced in weight by a total amount of 1841.2 gm.
- (4) The material developed by the abrasion consists of extremely fine-grained material lying almost entirely between the limits of 0.07 mm to 0.0004 mm.
- (5) With prolonged treatment the different grades of the gravel were reduced to certain definite proportions which remain constant. These are here termed the equilibrium proportions.
- (6) If any component grade is present in greater or less amount than its equilibrium proportion, it is decreased or increased rather quickly as the action proceeds.
- (7) When a sample is examined, it is found that there is practically no intermediate stage in the product of wearing between fine gravel (one-twentieth inch 1.18 mm) on the one hand, and silt 0.01 mm in diameter on the other. Nine-tenths of the material developed is fine silt and clay.
- (8) If the gravel originally contained much fine pebble—between  $\frac{1}{8}$  and  $\frac{1}{4}$  inches (3.4 and 6.3 mm), say 8% or more, wearing under the conditions employed actually produces a coarser sample of gravel, paradoxical as the statement may sound.
- (9) There is a slow tendency to produce a gravel of more uniform grade of intermediate sizes.
- (10) The shape of the pebbles under the conditions employed tends to become more rounded.
- (11) Noticeable fracture of pebbles takes place to a most limited extent.

#### IMPACT.

Consideration of the results of the wear of Sample A and Sample O showed that the loss of the finer constituents  $\frac{1}{4}$  to  $\frac{1}{8}$  inch (6.3 to 3.4 mm) could not reasonably be ascribed to abrasion since there was no corresponding increase in the quantity of the grades finer than  $\frac{1}{8}$  inch (3.4 mm). In fact after the experiments had been continued for 48 hours the percentages of these in Sample A showed no increase, though the decrease in the quantity of  $\frac{1}{4}$  inch to  $\frac{1}{8}$  inch grade (6.3 to 3.4 mm) continued to be important.

It seemed that impact or the crushing of the smaller pebbles by the larger ones was the only other cause that could account for the continued loss of the grade between  $\frac{1}{4}$  and  $\frac{1}{8}$  inch (6.3 to 3.4 mm). In discussing this action of crushing of the smaller pebbles the coarse gravel which does the crushing is called "the impactor" and the finer gravel which is crushed by the action is termed "the impactee" for the purposes of this paper.

In order to test this idea experiments were made with a sample consisting of 4500 gm. of gravel between  $\frac{1}{4}$  and  $1\frac{1}{2}$  inches (19 to 38 mm) with 500 gm. of fine gravel one-twentieth to one-eighth inches (1.18 to 3.4 mm). Sample N, Table 6. When this was treated for 24 hours it was found that hardly any of the finer grade or impactee one-twentieth to one eighth inch (1.18 to 3.4 mm) remained. No satisfactory conclusion as to the rate of the action could be derived from this experiment and it was therefore begun anew, but the sample was dried, graded and weighed after each hour's run, and after each hour all material finer than 0.04 mm was discarded. The early results (each of the first three periods of one hour) showed a rapid loss of the impactee but of this loss which amounted to 93.3 gm. in the first hour and 48 gm. in the third only about 7% graded between 1.18 and 0.07 mm and only 2% in the wide interval between 0.59 mm and 0.149 mm. In other words 93% of the loss was composed of material finer than 0.07 mm.

It was suggested that the silt and clay, or the material below 0.04 mm, was derived from abrasion of the impactee; and though this seemed highly improbable, it was decided to settle the doubt by an actual counting of the pebbles of which the impactee was composed. An equivalent sample of the original material was taken, and it was found that the 500 gm. contained 28,965 pebbles, this number being derived from counting the pebbles in a small sample taken from the 500 gm. After four periods of hourly run, a fresh sampling showed that this number had been reduced to 16,040 pebbles. It was remarkable that the average weight of the individual pebbles was slightly greater than at the beginning of the experiment. This proved conclusively that the loss was not due to mere abrasion but to the destruction of the smaller pebbles in the sample by impact, and showed that the action was selective in its nature, and that the larger pebbles on the average survived. The tests of this sample were continued for a total of 15 one hour periods, and the results obtained in the earlier periods were maintained in all detail throughout. At the end of 15 hours 379 gm. of impactee ( $\frac{1}{8}$  to  $1/10$  inches—3.4 to 2.0 mm) had been reduced to 44.5 gm. and the number of pebbles from 28,965 to 1,868. The average weight of the pebbles in this grade after 15 hours was finally 0.0238 gm. and at the beginning of the first hour 0.022 gm. At the end of the same period 121 gm. of gravel  $1/10$  to  $1/20$  inches—2.0 to 1.18 mm) had been reduced to 19.6 gm. while the average weight was changed from 0.011 gm. to 0.0076 gm. The whole of the grading for the 15 different hour periods is given in Table 6. This Table shows some irregularities in the numbers of the pebbles, but this must be ascribed to unsatisfactory sampling. After the

ninth hour-period of test, sampling was abandoned and the whole of each batch of pebbles was counted.

The feature previously noticed that a small amount of material only graded between one-twentieth and one-two-hundredth inches (1.18 to 0.0074 mm) was maintained throughout the tests. Not only is this the case, but the quantity in each grade maintained its proportion with minute and persistent regularity, in each of the 15 hour periods. A peculiar feature in the table is the slightly higher weight graded between one-sixtieth and one-seventieth inch (0.250 to 0.210 mm) than in the grades respectively finer and coarser than this. This seemed incongruous, and the openings in the sieves employed were therefore measured and it was found that the one-seventieth inch sieve had an opening of 0.192 mm instead of the standard 0.210 mm. In consequence of this, much of the material that should have passed through this sieve and have been retained on one-eightieth inch (0.177 mm) was actually retained on one-seventieth. In all the tables given, the actual openings of the sieves that were employed are stated in millimetres. The values suggested in fractions of inches are not exact.

The results of all the gradings and weighings throughout the tests of Sample N are remarkably accordant, and indicate that in spite of the rough nature of the apparatus employed the errors were reduced to a minimum.

Further tests were made in attempts to find a relative measure for the rate of the action due to impact. Sample K Table 5 which has been referred to previously under "Abrasion" shows clearly that impact has been commenced by the action of an impactor  $1\frac{1}{2}$  to 2 inches grade (38.1 to 50.8 mm) on an impactee as coarse as  $\frac{1}{2}$  to  $\frac{1}{4}$  inch (12.7 to 6.3 mm) which was treated for 24 hours. In this case the loss of 234 gm. during the period of treatment is relatively low, and shows that the action of impact on such a coarse grade of material is slight with the amount of fall obtained during the movement of the apparatus.

Sample P Table 3 shows how much more rapid this action became when the same impactor was used with a finer impactee  $\frac{1}{4}$  to  $\frac{1}{8}$  inch (6.3 to 3.4 mm). The loss amounted to 105.4 gm. in one hour, but of this 25 gm. was coarser than 0.59 mm and 59 gm. was finer than 0.07 mm. The loss in this case was not quite so great as in Sample N, where both the impactor and the impactee were of a finer grade. In this sample the number of pebbles in the impactee were reduced in one hour from 5,270 to 3,510, while the average weight of these small pebbles rose from 0.97 to 1.12 gm. This result was emphasized by giving another hour's treatment, and it was found that the grades of material between  $\frac{1}{8}$  and  $1/30$  inch (3.4 to 0.5 mm) decreased slightly in weight in accord with the decrease in weight of the whole quantity of impactee, but remained practically constant when compared with the values after the first hour's treatment. In other words the quantities of the grades  $1/8$ th to  $1/10$ th inch (3.4 to 2.0 mm) and  $1/10$ th to  $1/20$ th inch (2.0 to 1.18 mm) and  $1/20$ th to  $1/30$ th inch (0.59 to 0.42 mm) had already attained their equilibrium proportions for the particular sample at the end of one

hour. It is clear that in this sample impact caused the destruction of pebbles  $\frac{1}{8}$  inch in diameter and perhaps rather larger than this. The increase in the weight of the average pebble of the impactee after an hour's treatment shows that impact was markedly selective.

It is probable that impact accounts for the loss in Sample H Table 5 which is distinctly higher than that of Sample C and of Sample L Table 5. Only a small amount of impact, however, could result from the movement of such a fine-grained impactor, under the conditions of experiment.

Further tests were undertaken in order to obtain more exact ideas as to the rapidity and the limits of the effect of impact.

Sample Q Table 3 consisting of 4500 gm.  $\frac{3}{4}$  to 1 inch (19.0 to 25.4 mm) and 500 gm of  $\frac{1}{8}$  to  $1/10$  inch (3.4 to 2.0 mm) was treated. After rotation for one hour the 500 gm. were reduced to 462.5 gm., a loss of 37.5 gm. but 23.32 gm. of this was not finer than 1.18 mm. It is therefore clear that this impactor which averaged  $\frac{7}{8}$  inches in diameter (23.8 mm) was far less effective than an impactor of an average  $1\frac{1}{4}$  inch (31.7 mm) Sample S. In other words, a decrease in the diameter of the impactor by 24% decreased the effect of the action in the ratio of 130 : 37.

Another sample, R Table 3, consisted of 4500 gms. of  $\frac{3}{4}$  to 1 inch (19.0 to 25.4 mm.) with 500 gms.  $1/10$ th to  $1/20$ th (2.0 to 1.18 mm.). Comparison with Sample Q shows that the average size of the impactee was reduced from  $9/80$ th of an inch to  $6/80$ ths while impactor of the same grade was used. In this case the effect of impact was increased in the ratio of 37 : 54.

The following tabulation gives a rough idea of the changes in the effect of impact when the grade of the impactor and the impactee are varied:—

#### ONE HOUR TREATMENT.

Impactor	Impactee	Weight of Material due to Impact Finer than	
		(1.18 mm $1/20$ " )	(0.59 mm. $1/30$ " )
Av. Size $1\frac{1}{4}$ " 47.6 mm.	$\frac{1}{8}$ " 5.1 mm.	82.9 gm.	72 gm.
„ $1\frac{0}{8}$ " 34.0 mm.	$\frac{8}{80}$ " 3.0 mm.	73.1 gm.	68 gm.
„ $\frac{7}{8}$ " 23.8 mm.	$\frac{8}{80}$ " 3.0 mm.	14.0 gm.	13 gm.
„ $\frac{7}{8}$ " 23.8 mm.	$\frac{8}{80}$ " 2.0 mm.	54.0 gm.	48 gm.

From these figures we get the rough indication that if the average diameter of the impactor varies from 7 to 10 the effect of impact varies from 1 to 5. If the size of the impactee varies from 6 to 9 the effect falls from 4 to 1. These figures obviously apply only to the particular conditions of movement used in the experiments and to the material employed. They indicate the importance of the action of impact in the destruction of gravel on a beach and show the rapidity with which it tends to eliminate the finer material in a mixed gravel. On the other hand, experiments on the abrasion of

fine material of a uniform grade as shown in Table 5 Sample C, H and L indicate that in the absence of coarse material the destructive effect of the movement is small.

This greywacke rock under the conditions employed suffers little from impact if the diameter of the impactee is  $1/10$ th or more of the diameter of the impactor. If the impactor is coarse, the impactee will be attacked even when relatively larger. The effect, however, is great when the relative diameter of the impactee falls to  $1/15$ th of the other. As has been stated previously the presence of material of intermediate grades tends to protect the impactee from the action of the impactor in a very marked degree.

Impact has been shown to be a most important action in connection with the wearing of gravel, and in general acts rapidly in reducing the percentage of the fine constituents. There is, however, a definite limit to its action. Thus if Sample A Table 1 is studied, it is at once seen that when the constituent grade  $\frac{1}{4}$  to  $\frac{1}{2}$  inch (6.3 to 3.4 mm) has been reduced to 7%, approximately, of the weight of the sample, it remains constant at that amount; in other words, the effect of impact is no longer noticeable. In Sample B the amount of this constituent constantly increased from 3.4% to 5.2%. Here impact failed to prevent an increase in the percentage of this constituent. In sample O where the impactee was at first 20% there was a constant decrease to 15.7%. In Sample N the loss of this constituent during the second hour was 14.5% and in the fifteenth hour 10%.

These results are remarkably accordant, and show that when the percentage of impactee is less than the proportion of equilibrium for the particular sample, the effect of impact is no longer apparent, and in general the rapidity of the action of impact depends upon the excess of the impactee above the equilibrium proportion.

Another point is noticeable. In a mixed gravel such as Sample A, a higher percentage of impactee actually amounting to 7% is required for the equilibrium proportion than in Sample N which has no material of grades between 1 inch and  $\frac{1}{2}$  inch (25.4 to 3.4 mm). The equilibrium proportion here is less than 1.3%. This supports the conclusion that material of intermediate grade protects the impactee from the effect of impact, but experiments were not carried far enough to determine the nature and amount of its protection.

The following notes were made in regard to the nature of the materials, in Sample N (Table 6), of the minute quantities of the sands graded from  $1/30$ th inch to  $1/200$ th inch (0.59-0.07 mm). In the coarser grades quartz was not predominant; but in those finer than  $1/60$  inch (0.24 mm) it attained 80-90 per cent. At  $1/100$ th inch (0.14 mm) muscovite became noticeable, and was prominent at  $1/200$  inch (0.074 mm) though it could hardly be discovered in the rock.

#### GRINDING.

Further inspection of the wearing of Samples A, B and N, all showed a feature in common, that when action had taken place on

gravels variously graded, whether it lasted for one hour or for 24, or 48 there was always a minute proportion only of material between 1/30th and 1/100th inch (0.59 and 0.149 mm) while the amount between 1/20th and 1/200th inch (1.18 and 0.07 mm) was unimportant. This was the case even in those instances when one and a half grams and more were being reduced from the condition of fine gravel, to that of silt and clay every minute.

It is clear that the first effect of impact, must be mainly the production of grains of material between 1/20th and 1/200th inches; yet at any one time, the amount of material of this size in all of the samples, was found to be negligible. The suggestion is clearly that material of this grade was destroyed, almost directly it was formed, by some action which operated with great rapidity. Further experiments were made in order to ascertain the actual rate at which the fine gravel and sand were changed into silt and clay. A sample was first employed, consisting of 4,500 gm.  $1\frac{1}{2}$  to 1 inch, (38.1 to 25.4 mm), and 500 gm. of quartz-sand from Otago, which graded as follows:—

Sieve		mm. mm.	gm.
	20-40	1.18-0.42	7.3
	1/40-1/50	0.42-0.28	18.5
	1/50-1/60	0.28-0.24	37.2
	1/60-1/70	0.24-0.19	120.3
	1/70-1/80	0.19-0.17	32.5
	1/80-1/100	0.17-0.14	178.6
	1/100-1/200	0.14-0.07	94.8
	Passed 200		9.8

After this sample had been treated in the Deval Machine for 24 hours, 0.01 gm. of sand only were retained on the 200 inch sieve; while the material between 0.07 and 0.04 mm weighed 10 gm., that between 0.04 and 0.01 weighed 116 gm., and the material finer than 0.01 mm weighed 374 gm. It was clear from this experiment that the grinding action of the tube mill type was so rapid that shorter intervals of time were required for experiment. A sample was therefore employed consisting of the gravel used previously, with 500 gm. of quartz-sand, graded from 1/60th to 1/70th (0.25 to 0.19 mm) and treated for one hour. It then graded as is shown in Table 7 Sample J (2). All of the sand was lowered in grade, and the greater part was reduced to extremely fine dimensions. It was treated for another half-hour, and was then practically all in a finer state than 0.07 mm. During the first hour, the gravel lost 14.6 gm., and in the second half-hour, 9 gm.; altogether a loss of 0.52% in  $1\frac{1}{2}$  hours. The result shows that gravels of this type, weighing 4,500 gm., will in  $1\frac{1}{2}$  hours grind 500 gm. of sand into a fine condition, for all but 26 gm., were finer than 0.07 mm. The grinding action is, therefore, far more rapid than abrasion or the effect of impact. When pebbles, 1 inch to  $1\frac{1}{2}$  inches (2.54 to 3.81 cm) are used, the grinding action begins with fragments of sand 1/30th inch, or 0.59 mm in diameter, and the grinding action continues until material is reduced to the state of silt and clay.

In all the experiments previously described greywacke rock was used. One additional experiment has been made with andesite pebbles collected near the mouth of the Wangaehu River (Table 8). These were graded in the same manner as Sample O, but the loss after 24 hours' treatment amounted to 816 gm. in place of 95 gm. from greywacke rock. Sample O Table 4. The andesite rock was slightly vesicular but the pebbles represented sound material, for they had travelled more than 100 miles down the river-valley from their source. In this experiment, by far the greatest amount of loss was from the material between  $\frac{1}{4}$  and  $\frac{1}{2}$  inch (6.3 to 3.4 mm), for the 1,000 gms. of this grade were reduced to 515 in the 24 hours. Although the effect of impact was so much more rapid and the coarser products of its action between  $\frac{1}{2}$  inch and  $1/20$ th (3.4 to 1.18 mm), that is, fine pebbles were in relatively large amount, the rest of the material, down to a grade of 0.04 mm was little larger than in a greywacke rock which lost only 95 gm. in 24 hours. The result clearly shows that notwithstanding the rapid rate of reduction of the finer pebbles by impact, the action of grinding was able to reduce the material supplied by impact as rapidly as it was provided.

#### SUMMARY.

The experiments detailed in this paper show that the reduction of gravel under the conditions of movement employed is due to three actions which are considered to be distinct—termed respectively—"Abrasion," "Impact," and "Grinding."

"Abrasion" is the mere effect of pebble rubbing against pebble.

"Impact" is the effect of definite blows of relatively large pebbles on others relatively small.

"Grinding" is the crushing of small grains by the continued contact and pressure of pebbles of relatively large size.

1. Abrasion is by far the slowest of these actions, and its amount varies from 6% of loss in 24 hours with coarse material (3.81 to 5.08 cm), to 0.6% with fine material (0.63 to 0.34 cm).

2. Impact acts far more rapidly than abrasion, but only when the impactor has ten times or more the diameter of the impactee. It may then cause a loss of 10% to 16% of the impactee in one hour, when the proportion of impactor and impactee are 9 : 1. At the same time, this action increases the rate of wear of the impactor, though much of this wear may be due to the subsequent grinding of the small fragments due to impact. In Sample N Table 6 the loss of the impactor is 0.2% per hour, or 4.8% in 24 hours, in place of 2.9% in 24 hours, when such gravel is used by itself. In this sample the materials would lose 2.8% in 24 hours, if used separately, but when they are treated together, impact causes the effect to increase 16 times.

3. Grinding is by far the most rapid action under the conditions of experiment. In the test that was made, the loss was 523 gm. in  $1\frac{1}{2}$  hours. If sand were continuously supplied, the loss

would be at the rate of 8,368 gm. in 24 hours. Calculations show that if 12,500 gm. of gravel and sand were used, under such conditions, the silt and clay that would be produced would amount to 66.5% in 24 hours.

It follows that loss by abrasion of beach pebbles, formed of uniform hard greywacke, amounts to 1.5% in 24 hours. The movement during the experiment being roughly equivalent to 24 miles of travel. Impact may produce waste sixteen times as rapidly as abrasion, while grinding, acts  $2\frac{1}{2}$  times as rapidly as impact.

It is clear from the above (1) that when gravel from  $\frac{3}{4}$  of an inch upwards is moving on a beach, the fine gravel,  $1/10$ th of an inch and less must soon be eliminated. (2) Sand cannot live on a beach where wave action keeps gravel in movement.

It is hoped to consider the nature of the materials on some typical beaches in New Zealand, in the light of these results that have been obtained from experiment. The preliminary statement can now be made, that gradings of gravel samples taken from definite spots on beaches where gravel has travelled 5 to 50 miles, show results that are in clear accord with those obtained by experiment.

It must once more be emphasized that the experiments described in this paper apply with one exception to rock of a single type only, and to one set of conditions only. There would obviously be great differences from the results described in this paper if different material was employed and if the conditions varied in relation to velocity of movement, diameter of cylinder, inclination of cylinder, proportions of charges, amount of water used, soluble substances in the water. It is thought, however, that the experiments are sufficiently varied to justify the conclusion that such differences would be variations in degree, not in kind.

Mr. B. Elphick, B.Sc., London, my assistant, has conducted the experiments with great care and understanding, and has made many valuable suggestions.

GS.

SAMPLE A.

TABLE 1.

Abrasion test of 5000 grams of gravel from Napier, weighed and graded every twenty-four hours.

Grades.		Original.	24 hrs.	48 hrs.	72 hrs.	96 hrs.	120 hrs.	144 hrs.
Inches.	Mm.	%	%	%	%	%	%	%
1/20 -	1.18 -	Not separated	Not separated	Not separated	Not separated	Not separated	Not separated	Not separated
1/10 - 1/20	2.0 - 1.18			6.3	4.3	3.9	3.2	3.0
1/8 - 1/10	3.4 - 2.0		11.2 } 7.8	21.3 } 7.7	18.2 } 7.5	14.7 } 7.3	12.5 } 7.1	13.0 } 7.0
1 - 1/8	6.3 - 3.4	441 - 8.82	363.8	336.2	325.3	316.5	306.2	294.0
1 - 1/4	12.7 - 6.3	1287 - 25.75	1226.0 - 25.5	1211 - 25.7	1188 - 25.6	1169 - 25.6	1154 - 25.6	1130 - 25.5
1 - 1/2	19.0 - 12.7	1257 - 25.14	1249.3 - 26.0	1217 - 25.8	1235 - 26.6	1190 - 26.1	1175 - 26.1	1169 - 26.4
1 - 3/4	25.4 - 19.0	914 - 18.28	904.8 - 18.3	899 - 19.1	872 - 18.8	887 - 19.2	867 - 19.2	842 - 19.1
1 1/2 - 1	38.1 - 25.4	636 - 12.72	672.7 - 13.9	650 - 14.0	622 - 13.4	652 - 14.3	710 - 15.8	704 - 15.6
2 - 1 1/2	50.0 - 38.1	461 - 9.22	375.2 - 7.8	372 - 7.9	369 - 7.9	333 - 7.3	268 - 5.9	266 - 5.9
Total weight		4996	4803	4712.8	4633.8	4565.6	4495.9	4421
Loss			193.5	90.2	77	68	70	74.8
Percentage Loss			3.88	1.88	1.64	1.47	1.53	1.69
Total Loss			193.5	283.7	360.7	428.7	498.7	573.5
Total Percentage Loss			3.88	5.7	7.2	8.6	9.8	10.5

TABLE 1—continued.  
Abrasion test of 5000 grams of gravel from Napier, weighed and graded every twenty-four hours.

168 hrs. %	192 hrs. %	216 hrs. %	240 hrs. %	9 hrs. in 3 periods.	24 hrs. saltwater.	312 hrs. %	336 hrs. %	360 hrs. %
0.2	0.13	0.2	0.28	0.14	0.10	0.15	0.10	0.10
2.0	2.4	2.1	2.0	1.65	1.55	1.85	1.6	1.5
11.5	11.1	10.7	9.5	9.5	10.05	11.1	10.2	8.0
300	295.7	289.7	283.0	281.1	272.5	276.3	270.1	262.2
1111 - 25.4	1089 - 25.3	1063 - 25.1	1033 - 24.9	1027.5	1022.8 - 25.0	997.7 - 24.7	987.7 - 24.4	964.6 - 24.5
1161 - 26.8	1139 - 26.4	1125 - 26.5	1099.5 - 26.5	1088.5	1079.6 - 26.4	1060.1 - 26.4	1057.4 - 26.5	1060.7 - 26.9
817 - 18.5	817 - 18.9	798.2 - 18.8	798 - 19.2	800.7	790.9 - 19.3	785.3 - 19.4	748.7 - 18.9	746.5 - 18.96
699 - 16.0	722 - 16.8	717.5 - 16.9	689.4 - 16.6	687.5	684.8 - 16.7	724.8 - 17.9	739.1 - 18.5	715.0 - 18.3
264 - 6.0	234 - 5.5	231.4 - 5.4	227.7 - 5.5	226.8	225.7 - 5.5	179.3 - 4.2	177.8 - 4.4	176.8 - 4.4
4365.7	4310.33	4237.8	4142.38	4123.39	4088.00	4036.60	3983.7	3934.8
55.25	55.47	72.53	95.42	—	35.39	51.40	42.9	48.9
1.24	1.27	1.68	2.25	—	0.71	1.24	1.06	1.25
630.8	686.7	758.5	854.12	872.61	908.0	959.4	1016.3	1061.2
12.7	13.8	15.1	17.1	—	18.1	19.2	20.3	1.25

SAMPLE B.

TABLE 2.

Abrasion test of 5000 grams of gravel from Napier, weighed and graded every forty-eight hours.

Grades.		Original	%	48 hrs.	%	96 hrs.	%	144 hrs.	%	192 hrs.	%
Inches.	Mm.										
1/20 -	1.18 -					0.3 -		0.7 -		0.4 -	
1/10 - 1/20	2.0 - 1.18			1.3 -		1.5 -		1.3 -		1.3 -	
1/4 - 1/10	6.3 - 2.0		3.41	185.6 -	3.9	197.5 -		200.3 -		202 -	4.4
1/2 - 1/4	12.7 - 6.3										
3/4 - 1/2	19.0 - 12.7		33.83	1691.3 -	34.0	1603 -	33.4	1575 -	33.5	1537 -	33.4
1 - 3/4	25.4 - 19.0		31.81	1590.4 -	31.8	1531 -	31.9	1491 -	31.8	1479 -	32.2
1 1/2 - 1	38.1 - 25.4		18.41	862.9 -	17.7	846 -	17.6	818 -	17.4	775.7 -	16.9
2 - 1 1/2	50.8 - 38.1		4.74	234.6 -	4.8	266 -	5.5	263 -	5.6	261.2 -	5.7
2 1/2 - 2	63.0 - 50.8		3.19	240.9 -	5.0	205 -	4.1	202 -	4.3	198.4 -	4.3
Total Weight	- - -		4.61	143.3 -	2.9	142 -	3.0	141 -	3.0	140 -	3.0
		5000		4880.3		4792.3		4692.3		4593	
Loss				119.7		88		100		99.3	
Percentage loss				2.39		1.9		2.1		2.1	
Total loss				119.7		207.7		307.7		407	
Total percentage loss				2.39		4.1		6.1		8.1	



GS.

TABLE 3.

## NAPIER SHINGLE.

Sample		Wt Gm.	Grading Inches		Loss of Weight of Gravel in One Hour		
P		4,500 500	$1\frac{1}{2}$ - 2 $\frac{1}{8}$ - $\frac{1}{4}$		22 gm.		
Q		4,500 500	$\frac{3}{4}$ - 1 $\frac{1}{8}$ - $\frac{1}{10}$		5 gm.		
R		4,500 500	$\frac{3}{4}$ - 1 $\frac{1}{10}$ - $\frac{1}{20}$		6 gm.		
S		4,500 500	$1\frac{1}{2}$ - 1 $\frac{1}{8}$ - $\frac{1}{10}$		7 gm.		

GRADES		SAMPLE "P"		SAMPLE "Q"	SAMPLE "R"	SAMPLE "S"	
Mm.	Inches	1st hr. Wt. Gm.	2nd hr. Wt. Gm.	1 hr. Wt. Gm.	1 hr. Wt. Gm.	1st hr. Wt. Gm.	2nd hr. Wt. Gm.
6.3 - 3.4	$\frac{1}{4}$ - $\frac{1}{8}$	394.6	353.6				
3.4 - 2.0	$\frac{1}{8}$ - $\frac{1}{10}$	22.1	19.63	462.5	...	369.8	298.3
2.0 - 1.2	$\frac{1}{10}$ - $\frac{1}{20}$	11.0	9.37	23.32	446	57.1	60.7
0.84 - 0.59	$\frac{1}{20}$ - $\frac{1}{30}$	1.85	1.48	0.68	6.88	3.35	3.65
0.59 - 0.42	$\frac{1}{30}$ - $\frac{1}{40}$	0.58	0.45	0.11	2.35		
0.42 - 0.30	$\frac{1}{40}$ - $\frac{1}{50}$	0.56	0.45	0.08			
0.30 - 0.25	$\frac{1}{50}$ - $\frac{1}{60}$	0.37	0.27	0.27		2.33	2.05
0.25 - 0.18	$\frac{1}{60}$ - $\frac{1}{80}$	0.66	0.55				
0.18 - 0.15	$\frac{1}{80}$ - $\frac{1}{100}$	0.98	0.97		0.37	0.81	0.61
0.15 - 0.07	$\frac{1}{100}$ - $\frac{1}{200}$	7.12	5.78	0.30	2.12	4.12	4.05
0.07 - 0.04	...	25.15	24.34	1.92	11.53	22.67	24.72
0.04 - 0.01	...	25.85	34.65	4.28	14.74	18.63	35.35

TABLE 4  
NAPIER SHINGLE.  
Even graded sample from  $1\frac{1}{2}$  inches -  $\frac{1}{8}$  inch 38.1 - 3.4m.m.

M.M.	Inches.	Original.	24 hrs.	48 hrs.	72 hrs.	96 hrs.	120 hrs.	144 hrs.
0.84 - 0.04	$\frac{1}{20}$ - $\frac{1}{200}$	0.00	0.45	0.45	0.39	0.46	0.35	0.45
2.0 - 0.84	$\frac{1}{10}$ - $\frac{1}{20}$	0.00	4.9	6.0	6.1	6.8	5.6	6.05
3.4 - 2.0	$\frac{1}{8}$ - $\frac{1}{10}$	0.00	21.4	26.0	29.63	32.45	34.4	34.7
6.3 - 3.4	$\frac{1}{4}$ - $\frac{1}{8}$	1000.00	931.0	872.3	821.5	775.9	742.6	707.7
12.7 - 6.3	$\frac{1}{2}$ - $\frac{1}{4}$	1000	996.7	986.7	976	953.3	948.5	930.7
19.0 - 12.7	$\frac{3}{4}$ - $\frac{1}{2}$	1000	1019.6	986.9	971	968.45	959.6	953.6
25.4 - 19.0	1 - $\frac{3}{4}$	1000	941.2	950.4	935	928.5	916.8	899.8
38.1 - 25.4	$1\frac{1}{2}$ - 1	1000	993.5	987.9	981	976.0	959.1	953.4
		5000	4905	4813.65	4720.62	4641.86	4566.95	4486.40
Loss	- - -	-	95	92.65	93.03	78.76	75.91	80.55
Percentage Loss	- - -	-	1.9	1.9	1.9	1.7	1.6	1.8

G.S.

TABLE 5.  
ABRASION OF NAPIER SHINGLE.  
24 hour runs.

	Inches	Mm.	After 24 hrs.	
Sample F 5000 gms.	2 - 1½	50.8 - 38.1	Loss 259 gm.	<sup>%</sup> 6.0
Sample E 5000 gms.	1½ - 1	38.1 - 25.4	Loss 144 gm.	2.9
*Sample G 5000 gms.	1 - ¾	25.4 - 19.0	Loss 91	1.8
Sample D 5000 gms.	¾ - ½	19.0 - 12.7	Loss 61	1.2
Sample C 5000 gms.	½ - ¼	12.7 - 6.3	— 30	0.6
Sample H 5000 gms.	¼ - 1/10	6.3 - 2.0	— 40	0.8
Sample L 5000 gms.	¼ - ⅛	6.3 - 3.4	— 25	0.56
Sample K Original			After 24 hours	
2500 ... ..	1½ - 2	38.1 - 50.8	Loss 58 gm.	2.3
2500 ... ..	½ - ¼	12.7 - 6.3	Loss 234	9.4
	1/20 -	0.18 -	Wt. gm. 0.85	7.2
	1/10 - 1/20	2.0 - 0.8	3.2	
	⅛ - 1/10	3.4 - 2.0	8.5	
	¼ - ⅛	6.3 - 3.4	168.5	

\* Note on Sample G:

Repeat for 24 hours gave a loss of 72 gms.

> .074	.01 gm.
.074 - .04	0.17 gm.
.04 - .01	7.4 gm.
.01 - .002	32.1
< .002	46.8

Smallest particle formed .0004 mm.

The excess of 14.48 gms.  
is due to absorption of water  
and to the addition of iron  
dust from the apparatus.





TABLE 6—continued.

[illegible]

TABLE 6—continued.

Mm.	Inches.	Abrasion 11 hrs. (1 hr. without water)				Abrasion 12 hrs.				Abrasion 13 hrs.			
		Loss 4421 gm.*				Loss 4411 gm.				Loss 4403 gm.			
		Wt. gm.	%	No. of Pebbles.		Wt. gm.	%	No. of Pebbles (and wt.)		Wt. gm.	%	No. and wt. of Pebbles.	
25.4 - 38.1	1 - 1½	65.1	68.5	2770	28.08	59.83	70.1	2495	5.27	53.4	72.4	2240	6 4
19.0 - 25.4	¾ - 1	18.8	19.5	3631	12.70	19.50	22.8	.0235	.024	15.95	21.6	.0238	3.6
2.00 - 3.4	1/10 - 1/8	1.357	1.43	.0052		0.82	0.86	2819	+0.7	0.50	0.68	2205	
1.18 - 2.00	1/20 - 1/10	0.305				0.11		.0069				.0072	
0.69 - 0.18	1/30 - 1/20	0.250				0.07							
0.42 - 0.69	1/40 - 1/30	0.277				0.06	0.42			0.34	0.46		
0.28 - 0.42	1/50 - 1/40	0.435	2.02			0.045							
0.25 - 0.28	1/60 - 1/50	0.127				0.015							
0.19 - 0.25	1/70 - 1/60	0.530				0.065							
0.17 - 0.19	1/80 - 1/70	1.900	2.00			0.39	0.45			0.49	0.66		
0.14 - 0.17	1/100 - 1/80	5.500	5.8			4.43	5.20			2.89	3.92		
0.07 - 0.14	1/200 - 1/100	6.68				9.04				7.90			
0.04 - 0.07		32.0				9.646				11.66			
0.01 - 0.04													
- 0.01													

\*Adherent fine matter



GS.

TABLE 7.

Sample J<sub>2</sub>

Napier Shingle.

4500 grm. 1 in. - 1½ in. (2.54 - 3.81 mm.)

500 grm. quartz-sand from Dunedin graded 1/60 in. - 1/70 in. (0.245 - 0.192 mm.)

Treated for one hour.

Gravel 4485.4 gm.

Loss 14.6 or 2.9 %

Inches	Mm.	Weight
Sand 1/40 - 1/80	0.42 - 0.18	0.4 gm.
1/80 - 1/100	0.18 - 0.15	4.0
1/100 - 1/200	0.15 - 0.07	142.0
	0.07 - 0.04	211.0
	0.04 - -	143.0

Treated for an additional half-hour with exception of material finer than 0.04 mm.

Gravel 4476 gm.

Loss 9.4 gm.

Inches.	Mm.	Weight
Sand - 1/100	- - 0.15	0.07
1/100 - 1/200	0.15 - 0.07	26.0
	0.07 - 0.04	241.0
	0.04 - 0.01	55.3
	0.01 - .	34.0

TABLE 8.

Sample of Wangachhu gravel (Andesite).

Mm.	Inches	Original	After 24 hrs.
38.1 - 25.4	1½ - 1	1000	777.5
25.4 - 19.0	1 - ¾	1000	1066
19.0 - 12.7	¾ - ½	1000	864.5
12.7 - 6.3	½ - ¼	1000	878
6.3 - 3.4	¼ - ⅛	1000	515
3.4 - 2.0	⅛ - 1/10		59.66
2.0 - 1.18	1/10 - 1/20		14.98
1.18 - 0.59	1/20 - 1/30		1.50
0.59 - 0.42	1/30 - 1/40		0.38
0.42 - 0.28	1/40 - 1/50		0.27
0.28 - 0.25	1/50 - 1/60		0.18
0.25 - 0.19	1/60 - 1/80		0.27
0.19 - 0.17	1/80 - 1/100		0.37
0.17 - 0.07	1/100 - 1/200		0.97
0.07 - 0.04	1/200 - -		4.16
0.04 - -			816.6

## A Natrolite Tinguaita from Dunedin.

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[*Read before the Wellington Philosophical Institute, 7th September, 1927;*  
*received by Editor, 21st December, 1927; issued separately,*  
*19th March, 1928.*]

### PLATE 42.

IN 1906, the author published a general geological description of Otago Peninsula.\* Among the many types of rock that were mentioned a tinguaita was described as occurring at Hooper Inlet and the Fish Hatchery. In the description of this rock it was stated that "a peculiar spherulitic structure appears in the ground-mass. The mineral of which the spherulite is composed is highly birefringent — as highly as quartz — and is quite transparent. With ordinary light it is impossible to distinguish which part of the section is spherulitic. The spherulites between crossed nicols show an irregular black cross and the mineral of which they are composed is platy rather than fibrous."

A microscopic preparation of this rock was sent to Professor H. Rosenbush, who was good enough to make the following comment in manuscript. "Ein typische Tinguait. Die gemenge Saridin, Nephelin, Grundmasse ist in einer mit nach wie vorgekommen weise zeolitisiert und zwar (a) in Natrolith Spherulithe von grossen Dimensionen so dass zwischen gekreuzten Nicols bei schwacher Vergrösserungen Interferenzkreuze erscheinen deren Arme über der ganze Gesichtsfeld reichen. Der optische Character der Fasern ist positiv. (b) an Andestellen des schlicfs ist Nephelin und Sanidin in einen isotropen Zeolith umgewandelt, wohl Analcim."

A more complete examination of this rock has now been made in the field and in the laboratory. Three dykes actually occur. One of these is at the outer end of the Portobello Peninsula, about four feet in width, and is much weathered; but sound rock can be obtained. In this example the spherulites are 10mm. in diameter. A second dyke is on the north-east side of Hooper Inlet on the south headland of its most westerly bay. This is very decomposed, and sound rock cannot be obtained. The third dyke from which an abundance of sound rock can be obtained is also on the north-east side of Hooper Inlet half a mile further to the eastward.

In hand specimens the rock is dense with the dull-green colour that is so characteristic of tinguaites. Where the rock has been weathered greyish round spaces of the size of a pea become notice-

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\*P. Marshall, *The Geology of Dunedin, Q.J.G.S.*, 62, 1906, p. 394.

able, and if it has been subject to the action of salt water the round bodies are weathered out and a pitted surface is developed.

A microscopic section viewed in ordinary light seems a typical tinguaitite with a few long slender sanidine crystals which are crowded with inclusions. There are a few nepheline crystals with sharp boundaries and abundant slender microlites of aegerine augite widely separated by a transparent colourless mineral. In this, there are numerous extremely minute perfectly clear, but curved sanidine microlites. When viewed between crossed nicols it is at once seen that much of the colourless mineral is arranged in large radiating groups. It has a moderate birefringence measured as .012 while the index of refraction is lower than that of feldspar. The mineral agrees in all respects in its optical properties with natrolite. The transparent mineral which lies between the feldspar microlites is isotropic, and has a low refractive index, and is thought to be analcite. When a section is treated with silver-nitrate and afterwards with potassium-chromate the isotropic mineral becomes stained with silver-chromate.

As will be seen from the letter that the late Professor Rosenbush kindly sent me, that eminent authority thought that the zeolites were formed from a ground mass of nepheline and sanidine. This does not seem likely in view of the fact that perfectly fresh sanidine microlites penetrate into the ground mass everywhere. Feldspar laths also extend into the spherulites as well as perfectly fresh squares of nepheline. In addition it is noticeable that the finest needles of aegerine are quite unaltered and retain their fresh green transparency throughout. The inclusions in the crystals of feldspar are partly a colourless isotropic substance which is considered to be analcite, and also very fine needles of aegerine. All the crystals of the different minerals appear to be so fresh and clear that any mineral alteration since their original formation is most improbable.

The chemical composition of the rock is as follows:—

	A	B	C	D
Si O <sub>2</sub>	52.60	56.16	54.46	52.40
Ti O <sub>2</sub>	0.42	—	—	—
Al <sub>2</sub> O <sub>3</sub>	19.12	19.25	19.96	19.92
Fe <sub>2</sub> O <sub>3</sub>	4.32	4.77	2.34	3.83
Fe O	1.73	2.72	3.33	1.51
Ca O	1.50	1.26	2.12	1.34
Mg O	0.08	0.21	0.61	0.32
Na <sub>2</sub> O	10.80	6.08	8.68	11.71
K <sub>2</sub> O	4.05	4.66	2.76	4.10
P <sub>2</sub> O <sub>5</sub>	0.16	0.21	—	—
H <sub>2</sub> O	5.80	4.09	5.20	3.94
	<hr/> 100.58	<hr/> 99.41	<hr/> 99.46	<hr/> 99.07

A. Natrolite tinguaitite, Hooper Inlet, Dunedin, New Zealand,  
Anal. P. Marshall.

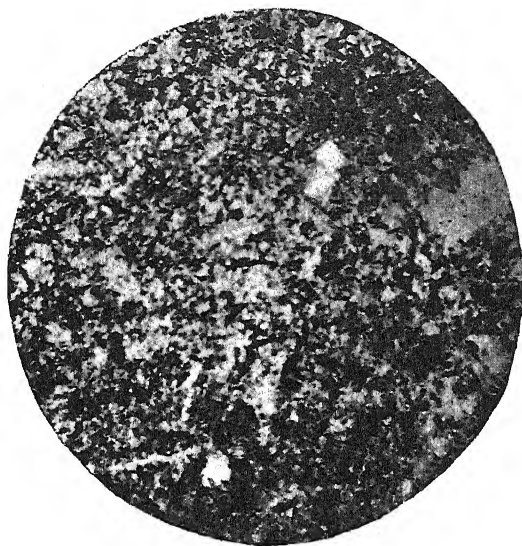


FIG. 1.—Thin section of natrolite tinguaita, Hooper Inlet, Dunedin,  $\times 30$ .  
Two small crystals of nepheline can be distinguished.



FIG. 2.—The same  $\times$  Nichols. The natrolite is distinctly seen to have a spherulitic development.



- B. Dyke of tinguaita, Acheron Point, Otago Harbour, New Zealand, *Q.J.G.S.*, Vol. 62, 1906, p. 395, Anal., P. Marshall.
- C. Tinguaita, Umtek, Kola, Rosenbush, *Elem. der Gest.*, 2nd edit. 1901, p. 233, No. 12.
- D. Tinguaita, Mt. Kosciusko, N.S.W. Anal., F. B. Guthrie, *Journ. and Proc. Roy. Soc. N.S.W.*, Vol. 35, 1901, p. 366.

Comparison with the analyses of tinguaites from Umptek and Mt. Kosciusko, N.S.W., shows that the rock is quite a typical tinguaita though the percentage of soda and of water are both high. It appears to be the case that in a rock of this nature the proportions of the silica, alumina, and alkali are such that a crystallization of feldspar and nepheline in some ratio accounts exactly for their relative amounts. Here, however, the relatively small amount of alumina compared with the high amount of soda and the high percentage of water has determined the crystallization of natrolite and analcite.

Though the percentage of water is high, it is not exceptionally so when the composition of this rock is compared with those of other tinguaites, as is shown above. Since the evidence appears to point conclusively to the opinion that the zeolites are original in this rock, the question arises whether original zeolites are present in other tinguaites. Rosenbush specially mentions that the nepheline changes to zeolites easily, usually to analcite, but he also makes the statement\* that analcite is never an original constituent of rocks.

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\*H. Rosenbush, *Gesteinlehre* Edit. 2, 1901, p. 224, and *Mikroskop Phys.*, 1905, Vol. 1, Hf. 2.

## Mineral Content of Pastures.

By B. C. ASTON, F.I.C., F.N.Z., Inst.

### Part 1.—Studies in Three Pasture Components.

#### INTRODUCTION.

IN the future one hopes for great benefits that an intensive study of the mineral content of New Zealand pastures will procure. The influence which a properly balanced mineral ration has on the health of stock is becoming better known, and cases are being reported in many countries of obscure diseases caused by diet deficiency. In New Zealand new instances are coming to light where the pasture apparently good to the eye does not produce the result hoped for in the stock grazed on the pasture. In the more pressing instances there is trouble which cannot be referred to any definite micro-organism or parasite, which does not spread on to adjoining lands, and does not infect other stock. The troubles are definitely referred to diet by experienced veterinarians, and it has been left to the chemist to determine what particular ingredient or ingredients are deficient. In advanced cases, a malnutrition affecting certain parts of the body may be diagnostic of certain elements lacking. Progressive anaemia affecting many stock on the same diet points to iron, and malnutrition of the bones indicates the bone-forming elements calcium and phosphorus as being respectively the deficient elements. If an extensive hairlessness in pigs or enlargement of the thyroid glands in dogs or horses occurred, one might suspect iodine deficiency. What the symptoms would be in the case of deficiency of some sixteen other elements which are considered essential to animal life, one cannot surmise. The study of such matters is in the preliminary stage, and it is only prolonged and systematic research of a peculiarly arduous and difficult nature that can throw light on the matter.

#### IRON STARVATION IN RUMINANTS.

The first and most important of these troubles in which the pasture is under the gravest suspicion, although to the eye good enough, is that of "iron-starvation" in the Rotorua and adjoining counties. It is not confined to New Zealand, and even here probably exists in areas other than the great inland plateau of the North Island.

The writer in 1924 (25) predicted that in three cases in other lands a mysterious disease would prove to be the same as "bush sickness." This is now being verified.

In King Island, off the coast of Tasmania, the Veterinary authority of that State (C. G. Dickinson, B.Sc.) has declared a disease called "coasty disease" (26) to be the same as "bush sickness" and to be curable by the same method, an iron-ammonium-

citrate remedy, or changing to "healthy," or, as they call it, "sound" country. The soil on which it occurs is a dune sand containing a large quantity of carbonate of lime (50 per cent. in the sample analyzed).

In the Kedong Valley, Masai Reserve, Nairobi, British East Africa, on a grey volcanic ash, the symptoms of a similar disease "Nakurutis" in cattle are the same as those of "bush sickness," and the authorities are now finding (personal communication) that it is curable by the same method, administration of iron and ammonium citrate.

In the Cheviot Hills, North Britain and elsewhere in that country, a disease called "pining," "vinquish," or "daising" in sheep has been known for over 100 years, having been accurately described by Hogg, "the Ettrick Shepherd." This occurs on pasture, according to Grimmett (personal communication) growing on a sandy silt soil (i.e. of the same type as the Mamaku soil). "Pining" animals respond to treatment with iron and ammonium citrate (27).

In treating "iron-starvation" in the following pages the writer would first like to quote the opinions of those who first studied the disease in the field, and show how their deductions have been verified. Their observations are forgotten, being buried in Departmental reports long out of print. The writer would like to pay his tribute to the veterinary profession, members of which have been indispensable in this work, and with whom for nearly 30 years the writer has worked in amicable and active co-operation. The eminently practical help rendered in the field has made the writer's work much easier, while their manly and frank personality has made it a pleasure to be associated with them.

#### SOME OLD OPINIONS, EXPERIMENTS, AND ADVICE.

The study of the deficiency disease for many years known as "bush sickness," "bush disease," "Tauranga disease," or "the skinnies," and now definitely and officially known as "iron-starvation" was commenced by the writer in 1900 at the request of the Government Chief Veterinarian, J. A. Gilruth (1). Several chemical analyses of soil, natural waters, and pasture plants were made from that date onwards to 1909, but the work was spasmodic owing to the difficulty of securing samples from a district not easily accessible and 400 miles from Wellington, and the matter not being recognized as so pressing as some other work of the Chemistry Division. Previous to the writer entering the field, the Government Veterinarian first appointed by the New Zealand Government, A. Park, 1898 (2), had made the suggestion that cases belonging to a settler at Arahiwi, (near Mamaku) might have been referred to any form of "anaemia or neglect," post mortem of one cow showing that no disease existed, and removal of other two cows to fresh pastures resulting in complete recovery without medicinal treatment. Park makes the statement that "this form of anaemia in cattle is apparently due to something deficient in the soil of that locality." He states that by changing the cattle to

good country and then returning them to the unhealthy country settlers may keep their stock in good condition. Park here gives the advice that every medical and veterinary practitioner would probably have given in an isolated case of anaemia to try iron medicine as the natural remedy for such cases. "If some of the settlers would take sufficient interest in their stock and administer carbonate of iron, we might see what could be done to improve the cattle on the pastures without removal, but until they do so and attend to details, I fear we must rely on what has been successful in practice, viz., change of pasture." He further (p. 92) discusses the same disease in sheep occurring at Tauranga. In this case also, he was unable to find any organic disease, and the experience is recorded that as in the case of cattle (at Arahīwi) the sheep do well for a time and fatten, but after five or six months pine away and if not removed soon die. "On the suggestion of Mr. Clifton, one pet lamb was treated with Parrish's Chemical Food (Syrup of Phosphates of Iron) and was said to improve a little but eventually pined away and died. Probably the green carbonate of iron as prepared by Burrows and Welcome may be found a suitable remedy, for it is said to be successful in the human subject in cases of anaemia, and very reliable."

Park's suggestions are given in extenso as showing that although he was alive to the remedy on general grounds for treating anaemia, the cause was yet to be determined. Anaemia may be caused by slow poison as well as by starvation, and until that "something wanting in the soil" as he puts it, or as we now should say, something wanting in the pasture, is ascertained, no logical treatment of the animal or pasture can be prescribed.

It was not until the iron sulphate-top-dressed pasture proved on sheep so efficacious in the Lichfield experiments, 1911/1912/13, (9) that the trial of iron medicines was indicated as a logically correct remedy for bush sick stock. The recovery of a ruminant under administration of iron remedies necessitates a long and tedious treatment—a matter of weeks rather than days elapsing before any improvement can be noticed. It is doubtful whether any advice to give iron medicine would have been persisted in had not the treatment been dictated by evidence provided from the chemical analysis of many samples of soils, pasture plants, and animal specimens, culminating in the successful Lichfield experiment. Again, when laying down that experiment, sulphate of iron was possibly the last thing that one would have thought of for a top-dressing unmixed with other manures unless iron deficiency were suspected. Hence it will be seen that any advice involving long and tedious treatment, is likely unless supported by strong reasons to be disregarded as, in point of fact, Park's advice in 1898 to try iron remedies was disregarded.

After mentioning the existence of the problem in the 1897 report, p. 68, where he used the word "pining," \* Gilruth, (3) 1899 recorded his examination of a few cases of "Tauranga or Bush

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\*A similar disease, in Scotland is known as "pining."

Sickness." Two sheep and one cow "revealed absolutely nothing which could be determined as causative of the progressive anaemia characteristic of the complaint." He speaks of the interest and perplexity of this disease and "promises experiments the following year." The experiments (4) are given in the 1900 report and are exceedingly interesting. The results have never been satisfactorily explained. Briefly they consisted in taking fifty sheep in November, from what were considered to be the worst of the mob belonging to the Thames Valley Estate and placing them on unhealthy\* land similar to country where they had been on since August. Thirteen of these sheep were taken to what is now Te Kauwhata in healthy country (a heavy clay loam soil) 109 miles from the unhealthy country, and placed on a bare ploughed paddock. Green food from affected land was cut and railed two or three times weekly to the 13 sheep on the bare paddock. These were in such a low condition when they arrived that some of them had to be carried from the trucks to the paddock. The fodder sent was coarse over-ripe grass, chiefly Yorkshire fog with a little fox-tail and red clover, and being sent only twice weekly was apt to heat before being used, yet the sheep improved in condition with the exception of the three very bad cases which had to be carried to the station. These lived a fortnight before dying. Unfortunately no post mortem was made. About a month after these were placed at Te Kauwhata, those in the "bush sick" area were inspected and a dozen found to have died, post mortem on one by Clayton showing anaemia with fatty liver but no other lesion. Gilruth visited the sheep in February, and found no trace of food growing on the paddock at Te Kauwhata, the animals being fed entirely on food now arriving three times a week, but not in quantity calculated sufficient to fatten any animal. The sheep were in poor condition but with a general appearance of health, and, were feeding with avidity on the fodder from the unhealthy country, thus having food similar in all respects to those on the unhealthy country, the only difference being the water supply. Gilruth next visited the control animals left in the bush sick country. In a small paddock under the immediate control of Mr. Wrigley, Tarukenga, who periodically forwarded the fodder to Te Kauwhata, all were found to be affected. One sheep had died and the others were emaciated and weak. Post mortem examination gave the usual result indicative of bush sickness. On the other paddocks in the bush only twelve sheep could be mustered out of the forty-two placed there in November, and these were similar to Wrigley's poor and emaciated, and post mortem gave the usual bush sickness indications. This experiment satisfied Gilruth that the herbage grown on the so-called sick country is not in itself inimical to the health of stock. Gilruth concluded that the remedy was to be sought for in a change in the system of management rather than in drugs or treatment of the land, at

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\*The words "healthy" and "unhealthy" applied to lands must be understood to refer respectively to those which are free from the disease and those on which it occurs.

least so far as sheep are concerned. He could only endorse the treatment already adopted by settlers in the district, of periodical changing of the stock from "sick" to what is known to be "healthy" country every few months. He quotes a report by the present writer showing that there was no poison in the water the stock drank, or in the pasture they ate, or the soil on which the pasture grew. These are the only occasions that Gilruth mentions the matter in his published report. Although he did not leave the Department's service until 1909, "bush sickness" is not again mentioned. On two occasions when he mentions it he uses the word "perplexing" and he wisely expresses no opinion as to the cause. It must not, however, be thought that this silence meant that nothing had been done. As a matter of fact much work was done but never published. Transfusions of blood tests and many post mortems were carried out by Gilruth, Clayton and Lyons, veterinarians assisted by Robert Alexander, subsequently Stock Inspector in charge of the Waikato. The names of these men are sufficient guarantee that the matter was thoroughly investigated from a veterinary point of view.

Official unpublished records show that in 1903 Gilruth reported:

"As a result of these experiments, I arrived at the following conclusions:—

(1) That the disease on the different properties is the same, and that the disease in cattle and sheep is similar.

(2) That the water-supply has no immediate bearing on the disease.

(3) That the disease is not due to any micro-organism, and is not in any way transmissible from animal to animal, even in direct inoculation of the blood of a sick animal into the veins of a healthy.

(4) That to the naked eye and under the microscope the tissues and the blood present no diseased condition, and that contrary to what one would expect especially from the rich looking pasture at Kaharoa everything points to a deficiency of some important constituent in the food-supply.

(5) That all animals become most rapidly affected on Kaharoa, next on Lichfield property, and least readily at Tauranga.

In 1905 (5) the writer reports having recently visited the bush sick area and collected samples of soils and blood of the affected animals. The bloods were taken by Clayton and Lyons from animals diagnosed as being in advanced stages of bush sickness. Previous to this, many analyses (6) had been made of the soils, pasture ash, and waters from the sick country, and are to be found in the Chemistry Division Reports, but they were made chiefly with the view of detecting any poisons which might be contained in the soil or the herbage, and so be consumed by the animal and lodged in its tissues. The idea of copper, the only element found to which suspicion could be attached, as being responsible was fully tested (6 "The Chemistry of Bush Sickness") and finally the possibility of there being any mineral poison respon-

sible was abandoned after exhaustive tests; see Dominion Laboratory Report (7) (15).

In the case of a mineral poison, it is difficult to believe that if this were being ingested with natural food, i.e., pasture, that the addition of a small amount of imported oats, bran, or linseed to the animals' diet would prevent the poison from ultimately exercising a poisonous effect on the animals. In the case of an organic poison, it seems improbable that the same compound could be produced in such differently related plants as the grasses on the one hand and the clovers on the other, and yet animals seem to develop bush sickness both on pasture which is largely clover or when it is largely grasses. There is also the difficulty of imagining any poison which could affect all ruminants and not other domestic herbivores, e.g., horses which remain continuously healthy on those types of soil growing the pasture which is most fatal to ruminants.

The field for enquiry was now narrowed down to the search for a deficient element in the food-supply. The analysis of the blood of animals in an advanced stage of "bush sickness" had shown that the elements phosphorus, potash and iron, characteristic of the blood corpuscles, were deficient (6). It was not to be thought that potash could be deficient in the food, as it was an abundant constituent of the pumice soils, and clovers (which absorb quantities of potash) are always present in the pasture of the affected country. For a considerable time, attention has been focussed on the possibility of phosphoric acid being the deficient element, a line of investigation which was sanctioned provisionally by a well-known professor of pharmacology whom the writer consulted personally in 1903, in England, and who gave it as his opinion after hearing the symptoms that the trouble was caused by an abnormality of the salts of the food. Accordingly in most of the experiments laid down on farms leased by the Department of Agriculture in the Rotorua county for finding a practical solution through application of top dressing to the pasture, phosphates were extensively used. This phosphate-deficiency hypothesis was supported by analysis of the soil and of cocksfoot grass, which was shown to contain a smaller amount of phosphate than is usual when grown on ordinary healthy country (14). Analysis of the sick animals' bones failed to show any deficiency of phosphate; moreover bone trouble has not been found to be a symptom connected with bush sickness, and one would expect a deficiency of phosphate sufficient to cause the death of a ruminant to show itself by malnutrition in the bones, which are the repository or storage organs for phosphates in the animal (20).

Experiments (8) with steers on pasture, which had as much top-dressing super-phosphate supplied as 7 cwt per acre, showed that although the animals benefited by the increased nutritive value of the pasture they could not be kept permanently healthy by that means. In two cases, bearing in mind the deficiency of iron found in the blood of the affected animals, the writer's suggestion was adopted and iron sulphate used as a manure to supply that element possibly deficient in the pasture.

Experiments (9) with sheep at Lichfield are recorded as follows:—"It will be noted that with sheep the best results were obtained from those depastured upon paddocks top-dressed with iron sulphate." In this case the ewes kept in excellent condition throughout and reared their lambs successfully with one exception, and that lamb had reached good marketable condition and could have been profitably sold before any indication of bush sickness was manifested by it. Further on the other two experiments in series 4 where no iron dressing was used all the lambs died; and in the adjacent control paddock not only did all the lambs die but also all the three hoggets and two of the five ewes on it. In the case of the other iron sulphate experiments with sheep it was unfortunate that one of the two animals used, died through accident. The other, however, maintained excellent health and condition for a long period, ultimately dying of bush sickness in January, 1913, nearly two years after it had been placed on the paddock at Martin's, Mamaku (series 3). That these experiments with iron sulphate were subsequently discounted by experiments with sheep where the treatment did not prove efficacious somewhat hindered the investigation, as in the eyes of the practical man the results appeared indefinite; but in the mind of the chemist two successful pasture experiments strengthened the suspicion that absolute deficiency of iron in the pasture was the cause of "bush sickness."

A new Director of the Veterinary Division, Dr. Reakes, had been appointed to succeed Gilruth in 1909, and had personally directed the field experiments with animals on different leased areas of "bush sick" lands. The leased areas were finally abandoned in favour of a Departmental farm at Mamaku for the sole study of the problem. Then came the war with the shortage of men, and the depression afterwards with shortage of money. This may be said to have thrown the investigation back some ten years; for it is not till 1924 that the writer (10) was able with any confidence to begin a series of articles in the *Journal of the Department of Agriculture*, setting forth a reasonable theory.

In 1912 (20), the writer had stated "about eight years\* ago I made analysis of sick animals' blood and found it extremely deficient in iron. Subsequent tests (6) confirmed that analysis; this together with analysis of soils and grasses, hinted that a deficiency of assimilable iron in the food might be the cause of the sickness. This suggested the application of iron compounds to the soil as a possible remedy. When therefore asked to suggest a series of schemes for top-dressing the pastures of the affected country, iron sulphate was recommended by me for two farms situated widely apart. It is significant that of all the substances experimented with iron sulphate applied alone to pasture has been the most successful in enabling sheep (the animal most susceptible to the sickness) to be kept healthy over a period of 18 months. This is the more remarkable as of the substances tried, phos-

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\*Actually in 1904.

phates, lime, potash, nitrates, and iron sulphate, the last is the one which would possibly not have been thought of had the analysis not suggested it. The opinions generally expressed by authorities are not favourable to the use of iron sulphate as a manure. Although essential to plant-growth, iron is required in such minute quantities that all soils are thought to contain sufficient. When iron sulphate proves beneficial, the result is generally regarded as due to an indirect action and not to the supply of the plant food, iron."

Another successful experiment in the use of an iron compound as a top-dressing was carried out at the Mamaku Farm. In this case the spent iron oxide from the gasworks was used, and the animals—sheep—were kept healthy for nearly two years on the paddock to which no other dressing had been applied.

During the interval in the research caused by the war, one thing had been proved. The administration of a suitable iron salt to a cattle beast in the proper proportion over a fairly long period would absolutely cure bush sickness, the food of the animal remaining unchanged. This discovery (11) was the direct result of the Lichfield experiment in indicating that iron was a remedy when applied to the pasture, and this in turn was the outcome of the analysis of the diseased animals' blood. The iron remedy first used with success was the syrup of phosphate of iron. Other iron salts were tried with a view to the adoption of one more easy to make and handle, notably the lactate, the tartrate and the double salt iron and ammonium citrate. No success was obtained at all with the lactate, but the tartrate gave good results; and finally the iron ammonium citrate was adopted and found perfectly reliable as a cure (12). This was a great step forward in the knowledge of the disease, and one which undoubtedly points to iron as being the deficient element in the food supply. Of the three radicles in this salt, iron, ammonium, and citric acid, iron is the only one likely to be deficient, since both ammonium and citric acid can be ruled out as a possible cure. The former has actually been tried as an ammonium chloride lick without effecting any improvement in a sick animal, and citric acid is present in all pasture.

It should here be pointed out that the anaemia is different from the isolated cases occurring in every medical practitioner's experience, where one individual in a group all getting the same food, becomes anaemic. In the case of "bush sickness" all the animals on the worst type of country will become in time anaemic, and if not removed or treated with concentrated food or medicines, all will assuredly die. With the iron treatment, if the animals, however badly affected, can be kept alive for a fortnight after the treatment commences, they will invariably recover.

Analyses of pasture plants collected in 1913 and 1914, from healthy and sick country clearly showed great differences in the iron content of the ash (13). In 1914, the writer again consulted an eminent British bio-chemist, who listened patiently to the description of the symptoms of "bush sickness" and finally said

"You find deficiency of iron in the soil growing the pasture, in the pasture feeding the stock, in the blood of the animal, and when you dose an animal with iron it recovers. What more proof do you want?" A good deal more is, however, required to be learnt and the results will possibly be of fundamental importance when the facts are fully established and will help to put on a firm foundation the proper treatment of pastures and the effect of differing types of soil on the pastures produced on them.

In order to eliminate other possible causes which may be co-operating to produce iron starvation, it is necessary to examine the influence of other minerals in the food supply including manganese and calcium. In South Africa a most puzzling deficiency disease was found in the end to have two causes and there is no reason why in a very great tract of country marked by universal low iron content in the soil, but where nevertheless there do occur patches of country where the disease is unknown, there may be some minor cause or causes operating to produce a milder type of disease or to prevent the occurrence entirely.

Much work has been accomplished at Mamaku Demonstration Farm (24), during the time it has been at work. Such great and permanent effects for good follow a liberal dressing with phosphate, as is shown by the well-established practice in the Waikato, that it seems needless to stress its general value at Mamuku in improving the carrying capacity, but the writer is convinced that, in addition, phosphate has an indirect action in ameliorating the incidence of bush sickness, although no iron is supplied in any commercial phosphate, except basic slag. A closer sward is formed, white clovers become more abundantly evident, and pasture plants have their root systems much stimulated, and, no doubt, are thereby enabled to absorb more iron from the soil. The porous soil contains abundant iron combined as silicate, and in this form one can only suggest that it is not available for the plant, or that if it does become available it is either oxidized to an insoluble state or that it is quickly leached away in a soil where the percolation is downward, and seldom or never upwards by capillary attraction.\* The analysis of the soil, however, is inconclusive owing to the difficulty of determining what iron is available for plant-growth. A much surer way of testing the matter is to ascertain what amount of iron the pasture contains compared with that grown on other lands which are known to be free from disease.

#### EXPERIMENTAL.

The composition of a fodder plant is influenced by three classes of facts (Warrington) namely those relating to:—

(a) The age of a plant, or to the relative development of the parts, leaves, stems, fruit, etc.

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\*This statement would apply equally to any soluble salt of iron used as a manure, and may account for the fleeting effect of ferrous sulphate on the pasture.

(b) The composition and physical condition of the soil in which the plant grows, which includes consideration of the manuring and the climate.

(c) The specific distinctness or the botanical relationship to other plants.

It is therefore desirable in studying the mineral composition of pasture to consider the effect of one varying condition at a time, the other conditions being as far as possible kept constant.

Accordingly, in the following account an endeavour is made to arrive at the truth, the enquiry being limited to three species of plants growing upon three or four types of soil in the same county, on both manured and unmanured ground. The stage of growth has been limited to what is known as well-grazed good cow-pasture and the samples, taken as far as possible throughout the whole year, have been carefully selected by Mr. Grimmett or the writer. They were cleaned of any sandy matter by quickly washing in water, a proceeding which may have resulted in loss of potash and soda, but these were not in any case estimated, and the error in other constituents estimated from washing is probably negligible. After drying, the samples were sent to the Wellington Chemical Laboratory where they were carefully picked over, neglecting woody stalks and any material foreign to the species being analyzed. In this way it is hoped that the botanical purity is guaranteed, but that the freedom from earthy contamination can be assumed is more than can be hoped. In some cases earthy impurities seem to adhere so tenaciously to the leaves that they cannot be eliminated by washing. After air-drying, the samples were dried in the hot water oven to a brittle state, which enabled the portions to be broken in the hands to a state fine enough for ten to twenty gram portions to be weighed with every probability of obtaining a fair sample.

In analyzing samples of fodder plants it is desirable to establish the presumption that a sample is pure and free from such contamination of earthy particles as would appreciably affect the results of any analysis for mineral foods it is sought to estimate. This precaution is especially necessary in the case of elements such as iron or manganese which exist to a much greater proportion in the soil than they do in the tissues of the pasture plant living on that soil. It is probable that ruminants cannot assimilate such mineral foods when they are present as earthy contamination.\* Such minerals it is thought must first be absorbed and be present in the tissues of the plant before the animal can absorb them. Iron, for instance, may exist in amount about one per cent. in a pumice soil and is extracted by the hydrochloric acid used in dissolving the plant ash. The amount of iron present in the tissues of dried grass is about 0.01 per cent. or one hundredth of what it is in the soil. It will easily be seen that a very small contamination of the grass with soil will make a very large error in the

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\*Experiments at Mamaku with iron salts of mineral acids suggest that they are not so assimilable as those in combination with organic acids.

estimation when the grass ash is analyzed. Half a gram of pumice in one hundred grams of dried grass will contribute therefore as large an amount of iron as .005 per cent. to the assay, an amount as large as the grass tissue may itself contain, involving an error which therefore doubles the true iron content.

In order then to guard against the effects of an impurity which all the precautions taken in sampling have not been able to exclude, the results of analysis have been classified into contaminated and uncontaminated samples. In the contaminated samples the amount of iron and manganese have been given, but these determinations are not to be accepted as representing the natural ash of the plant. On the other hand, the amount of phosphoric acid and lime occurring naturally in pumice soils is so small that contamination does not contribute an error large enough to swamp general conclusions, which may therefore safely be drawn from determinations in samples contaminated by earth.

In ascertaining from analysis what samples are and what are not contaminated the writer makes use of two facts, the content of silica and the content of alumina. The silica is absorbed by grasses to a much larger extent than by clovers, so that a different standard is required for each class of pasture plant. When the amount of silica is greater than a certain amount, it is valuable evidence of contamination by earthy siliceous matters. The estimation of alumina is especially valuable as a method of determining the purity of a pasture sample. Aluminium always accompanies iron in New Zealand soils, but it is only absorbed by the higher plants to which the fodders belong in very small traces. Hence if more than traces of aluminium are found in a solution of the ash of a pasture plant, one may conclude that it is contaminated by earthy matter, and that the iron determination should be disregarded as probably much too high. Probably also the manganese determination will be in error from the same cause.

As to the manner of stating the results, and the methods used in analysis, the calculations are all stated as percentages of the constituent calculated on the sample dried in the water-oven until the loss of reheating was inappreciable. The method is in conformity with that used by research workers in other parts of the world, and in the writer's opinion is justified by his experience. The methods of analysis used are official, or have stood the test of long experience in the writer's laboratory, and where any method was used other than that sanctioned by official publications it was checked by official methods by another operator. The writer would like to draw attention to the difficulty of obtaining a representative portion for analysis when dry grass or clover tissue of low specific gravity is contaminated with sandy or earthy material of much higher specific gravity. Contaminated samples must therefore be very carefully sampled, and in such cases check assays always made on duplicate weighed portions.

## DISCUSSION OF THE RESULTS.

The aim in analyzing the samples of pasture components was to obtain data from representative portions of the most commonly occurring plant staples in that condition in which they were actually being consumed by the ruminant. For the present the results reported refer only to cocksfoot grass, red clover, and white clover. It is hoped to extend the work in the future to other species, to pastures as a whole, and to inorganic constituents other than those upon which the work has hitherto been done.

It should be premised that "bush sickness" does not in the Rotorua County occur on land the top soil of which is finer than a sandy loam (22) and that although the practice of applying fertilizers, the nearness of the water-table to the surface and the packing of soil particles by running or lake water, and the admixture of "humus" may convert a coarse pumice soil to a healthy one for stock, it will be well to regard all soil types mentioned herein as suspicious except the sandy loams of Oturoa and Te Ngae, and the external samples. Another type of fine soil occurring in the Rotorua district is the silt soil of the Atiamuri Road. No pasture samples have, however, been received from there, but it is known to be healthy (23).

*Cocksfoots*—In the *uncontaminated, unmanured* cocksfoot grass (*Dactylis glomerata*) samples, it will be seen that the average iron content of the grass from the three coarse soils is the same (.014 per cent.  $\text{Fe}_2\text{O}_3$ ), while that of the loam soils is much higher (.017 to .020 per cent.  $\text{Fe}_2\text{O}_3$ ). The external samples from the Waikato and Wellington yield more than double the amount of iron found in those lowest in iron. The calcium content does not seem to vary much, and no general results can be drawn from the manganese average figures, and the magnesia figures are fairly constant. The lowest figures for phosphoric acid are, however, yielded by the unhealthiest soils, but the converse is not here true. In the *uncontaminated, manured* samples, the manuring, largely phosphates and iron, has increased the iron and phosphate content very appreciably, and has also increased the calcium when the plants are grown on the coarser soils. An analysis given of cocksfoots taken in June, from Te Ngae calcareous sandy loam, is interesting as showing the effect of washing the sample on the ash, silica, and alumina. The word "fusion" means that the sandy matter (undissolved by hydrochloric acid) was fused with sodium carbonate and the alumina determined in the resultant melt. All the other constituents except the nitrogen were estimated in the ash dissolved in dilute hydrochloric acid.

*Red Clovers*—In the *uncontaminated, unmanured* samples again is obtained definite evidence of the lack of iron in red clover, another important component of pasture on the pumice lands. The amounts of lime, magnesia, and phosphoric acid are fairly uniform in all samples. In the *contaminated* samples although the iron results must be disregarded, the phosphoric acid, calcium, and magnesium

results are valuable evidence. As one would expect, the amount of iron varies as the healthiness of the country; the healthier the country, the more iron, the less healthy the less iron in the uncontaminated samples.

*White clovers*—In the white clovers there is no woody stem produced, and one would expect less deviation due to stage of growth than occurs in the other two staples, cocksfoot and red clover. There is greater difficulty in securing samples of white clover, free from earthy contamination due to the lower-growing habit of the plant. The *uncontaminated, unmanured* samples show a smaller iron content in samples grown on coarser soil than those from the loams. The manuring has apparently raised the phosphoric acid content. Inserted here are two samples from loam-soil districts. Turakina and Pahiatua, far removed from the pumice lands.

One would place the above localities in the following order with regard to the incidence of bush sickness. Commencing with the unhealthiest and ending with those perfectly healthy:—

<i>Unhealthy</i>	(1) Kaharoa, Te Pu, and Kapakapa Road.
	(2) Mamaku.
	(3) Tauranga and Omanawa.
<i>Healthy</i>	(4) Oturoa
	(5) Ngongotaha lakeside and streamside.
	(6) Te Ngae Road.

The remedial treatment recommended in the treatment of iron starvation is given on page 181 of Part 1 of this volume.

The writer has to express his gratitude and thanks to all those skilled veterinarians already mentioned who have in the past lent their cordial co-operation and practical knowledge in helping onward the research, and especially to Dr. Reakes, Director-General of the Department, who has always taken a keen interest in "bush sickness," and has patiently directed the various resources at his command so that the work might go steadily forward; to Mr. J. Lyons, Director of the Live-Stock Division, and Mr. W. T. Collins, Auckland Superintendent, for their hearty assistance; to his own chemical staff the writer, in the early years, has been greatly indebted; to John Chilwell, F.I.C., Theodore Rigg, M.Sc., for valuable co-operation, and latterly to F. T. Leighton, L. D. Foster, M.Sc., R. E. R. Grimmett, M.Sc., and I. J. Cunningham, who have all worked with intelligence and enthusiasm. To Dr. J. B. Orr, D.S.O., M.C., etc., Director of the Rowett Institute Aberdeen, who has encouraged the writer to carry on with this work and has been most helpful with advice and support, the writer desires to express his deep obligation.

## RED CLOVERS.

(The figures are percentages on the material dried to constant weight on water-bath.)

## Uncontaminated, Unmanured.

No. of samples averaged.	Ash	CO <sub>2</sub>	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	CaO	MgO	Mn <sub>3</sub> O <sub>4</sub>	N.	Al <sub>2</sub> O <sub>3</sub>	Type of Soil	Locality.
7	9.40	1.97	.11	.011	.63	1.92	.70	.012	3.43	.020	Sandy silt and coarser	Manaku, Kaharoa, Ngongotaha Mountain
3	8.90	1.77	.18	.016	.73	1.90	.75	.008	3.98	.025	Coarse sand	Ngongotaha streamside
1	10.69	1.84	.21	.021	.83	2.01	.70	.012	4.74	.030	Calcareous sandy loam	Te Nga
4	9.68	1.63	.15	.014	.74	1.76	.59	.015	2.96	.022	Sandy loam	Oturoa

## Contaminated, Unmanured.

3	9.22	1.21	.51	.024	.79	1.37	.93	.016	...	.042	Fine gravelly sand	Kaharoa and Kapakapa
7	9.56	1.63	.25	.016	.81	1.76	.57	.015	4.23	.051	Sandy silt	Manaku
3	10.31	...	.42	.019	.87	1.71	.80	.033	...	.036	Coarse sand	Ngongotaha
3	10.49	1.85	.52	.027	.77	2.05	.67	.015	...	...	Calcareous sandy loam	Te Ngae
2	12.08	2.69	.18	.019	.68	2.35	.74	.017	...	.044	Sandy loam	Oturoa

## Uncontaminated, Manured.

3	10.21	...	.13	.024	.81	2.62	.82	.014	4.56	.033	Sandy silt	Manaku
2	...	...	.16	.013	.83	1.97	...	.016	...	...	...	Reporoa
1	10.09	...	.16	.017	.79	2.06	...	.009	...	.029	Sandy loam	Turakina Valley

## WHITE CLOVERS.

(The figures are percentages on the material dried to constant weight on water-bath.

Uncontaminated, Unmanured.

No. of Samples averaged.	Ash	CO <sub>2</sub>	Si O <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	Ca O	Mg O	Mn <sub>2</sub> O <sub>4</sub>	N	Fusion Al <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	Type of Soil.	Locality.
3	8.78	1.50	.16	.012	.78	1.98	.54	.011	4.26	.017	...	Fine gravelly sand ...	Kapakapa Rd., Kaharoa, Te Pu
4	10.94	1.99	.21	.017	.69	1.66	.60	.009	4.15	...	.021	Calcareous sandy loam	Te Ngae
4	10.43	1.91	.22	.017	.81	1.91	.53	.015	...	...	.021	Sandy loam ...	Oturoa

## Contaminated, Manured.

No. of Samples averaged.	Ash	CO <sub>2</sub>	Si O <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	Ca O	Mg O	Mn <sub>2</sub> O <sub>4</sub>	N	Fusion Al <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	Type of Soil.	Locality.
7	9.97	1.25	.37	.026	.93	1.80	.51	.010	...	.045	...	Various pumice types	Oturoa, Rotoma, Mamanuku, Rotorua, Kaingaroa Plains, Ngongotaha
3	9.48	1.01	.36	.028	1.10	1.50	.67	.014	...	...	.046	Sandy ...	Omanawa
3	11.38	1.70	.39	.033	.77	1.86	.60	...	...	.045	...	Calcareous sandy loam	Te Ngae
4	11.08	1.47	.41	.034	.86	1.52	.73	.009	...	.034	...	?	Pahiatua and Turakina

## Contaminated, Unmanured.

No. of Samples averaged.	Ash	CO <sub>2</sub>	Si O <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	Ca O	Mg O	Mn <sub>2</sub> O <sub>4</sub>	N	Fusion Al <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	Type of Soil.	Locality.
8	10.76	1.77	.31	.028	.84	1.88	.64	.030	4.25	.028	.051	Coarse Sand	Ngongotaha
3	9.38	1.49	.29	.020	.76	1.71	.50	.016	...	.031	...	Sandy loam	Oturoa
6	11.01	1.56	.27	.029	1.01	1.90	.57	.018	...	.036	...	Sandy silt	Mamaku
4	10.15	1.41	.45	.027	.96	1.57	.67	.039	...	...	.057	Fine gravelly sand	Te Ngae and Wairoa
6	9.98	1.43	.30	.019	.91	1.90	.61	.011	...	.025	...	...	Kapakapa Rd., Kaharoa and Te Pu
4	11.12	1.74	.34	.023	.81	2.07	.55	.015	...	.026	...	Loam ...	Ranfurly and Gisborne
8	10.98	1.55	.33	.037	.91	1.68	.61	.006	3.36	.072	.133	Sandy loam	Karori
1	12.15	1.83	.33	.037	.89	1.64	.59	.009	4.29	...	.034	Dune sand	Ohakune
1	9.22	1.54	.19	.020	.61	2.20	.58	.012	...	.005	.041	...	Himitangi

## AVERAGES OF SAMPLES ANALYSED.

## COCKSFOOT.

## Uncontaminated, Unmanured.

No. of Samples	Ash	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	CaO	MgO	MnO	N.	Fusion Al <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	Type of Soil	Locality.
8	10.72	2.55	.014	.46	.50	.43	.034	...	...	.043	Fine gravelly sand	Te Pu, Kaharoa, Kapakapa
11	10.27	2.26	.014	.50	.46	.40	.034	...	...	...	Sandy silt	Mamaku
3	10.90	2.36	.014	.65	.44	.41	.042	...	...	...	Coarse sand	Ngongotaha
7	11.30	2.91	.019	.61	.52	.53	.028	...	...	...	Sandy loam	Oturoa
6	10.83	3.42	.017	.53	.43	...	.021	...	.030	.019	Calcareous sandy loam	Te Ngae Road
1	10.88	3.00	.034	...	.38	.42	.027	...	...	...	Clay loam	Te Kauwhata
3	10.74	1.82	.029	.70	.43	.48	.015	...	.028	.034	Loam	Karori
4	10.39	2.94	.012	.50	.33	...	.026	...	...	...	Sandy silt	Tauranga and Omanawa

## Uncontaminated, Manured.

10	11.12	2.59	.020	.87	.64	.46	.031	...	...	...	Various pumice soils	Omanawa, Kaharoa, Rotorua

## Contaminated, Unmanured.

1	13.16	5.30	.042	.44	.46	...	.016	...	.027	.061	Calcareous sandy loam	Te Ngae (washed)
1	13.54	3.40	.046	.47	.41	...	.017	...	.145	.095	Calcareous sandy loam	Te Ngae (same sample as above but not washed.)
2	12.15	2.53	.021	.87	.73	.46	.023	...	.052	.053	Sandy silt and coarser	Mamaku and Kapakapa Road
5	10.90	3.26	.017	.62	.62	.41	.027	...	...	...	Coarse sand	Ngongotaha Lakeside and Mokio Island
4	12.90	3.16	.017	.50	.80	.44	...	...	...	...	Calcareous sandy loam	Te Ngae
1	14.50	3.04	.074	1.13	.47	...	.023	...	.045	.122	Loam	Karori

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## OBITUARY.

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### PERCY GATES MORGAN, 1867-1927.

The late Percy Gates Morgan, Director of the Geological Survey of New Zealand since 1911 was born in Tasmania in 1867, but came to New Zealand with his parents at an early age. He was educated at the Taieri Ferry State School and Otago Boys High School. He entered Otago University in 1885 as the holder of a Junior University Scholarship, obtained his B.A. in 1890 and his M.A. with honours in English in 1891. He also studied under the late Professor G. H. F. Ulrich at the Dunedin School of Mines, becoming an associate of that school in mining and receiving also a certificate in Mine and Land Surveying.

Between 1890-95 Mr. Morgan thoroughly learned the art of coal-mining as practised at Green Island. In 1895 he went to the Hauraki Goldfield, for a time worked in the deadly dry-crushing batteries then used in the southern part of that district, and in 1896 passed his examination as Battery Superintendent. In September 1896, he was appointed assistant lecturer at the Thames School of Mines, a position he resigned to become director of the newly established School of Mines at Waihi. He began his duties there on 1st July, 1897, and remained for nearly eight years.

In May, 1905, Mr. Morgan joined the staff of the New Zealand Geological Survey, then being re-organized by Dr. J. M. Bell, whom he followed as director in 1911. On 21st July, 1916, in addition to his other duties he took over the Under-Secretaryship of the Mines Department, having been already Acting Under-Secretary for three months. His inclination, however, did not lie in administrative work, and at his own request he was relieved of this position at the end of October 1917.

Mr. Morgan was an original member of the short-lived New Zealand Institute of Mining Engineers. For many years he was a member of the Australasian Institute of Mining Engineers, from 1901 to 1905 being on the council and acting as New Zealand correspondent: at the time of his death he was New Zealand's representative on the council. He was elected a fellow of the Geological Society of London in 1922. Mr. Morgan became a member of the Wellington Philosophical Society in 1909, was elected president in 1924 and acted for the society on the Board of Governors of the New Zealand Institute. He was also a member of the Australasian Association for the Advancement of Science, of the Seismological Society of America, and of the Society of Economic Geologists.

On becoming Director of the Geological Survey, Mr. Morgan was appointed to the Board of Examiners under the Coal Mines

and Mining Acts, and was elected chairman of that body. He was a member of the Board of Science and Art, and from time to time acted as an official representative on numerous commissions and boards.

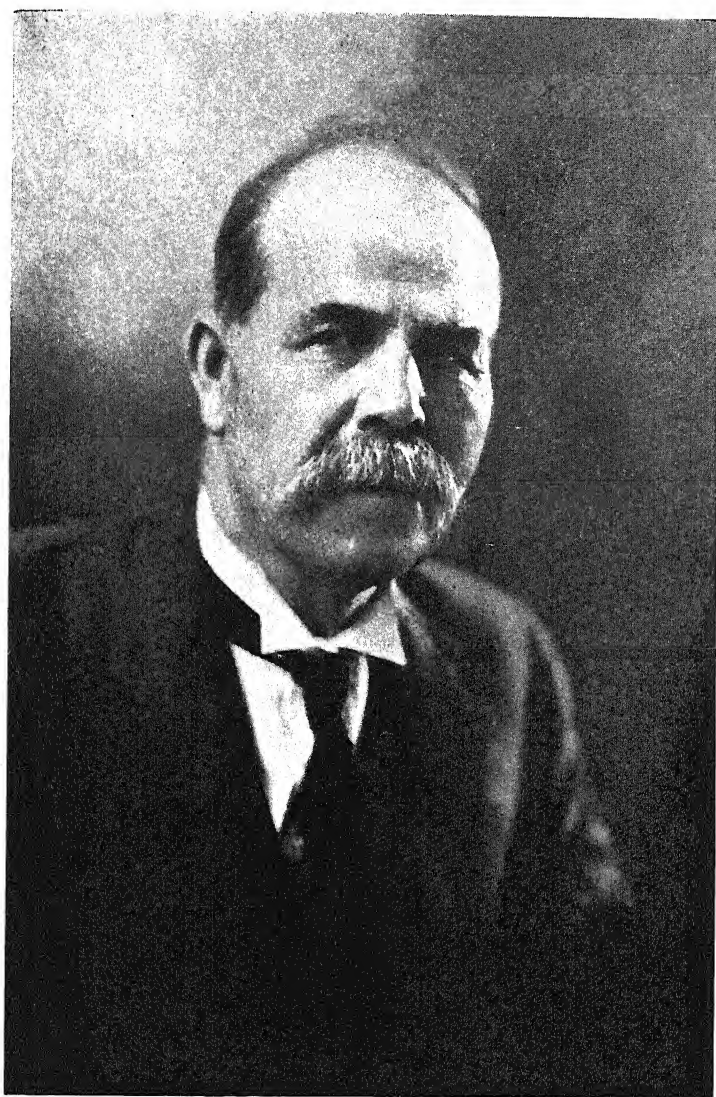
Mr. Morgan, who in 1900 married a daughter of the late Mr. Thomas Gilmour of Waihi, is survived by a widow and four daughters.

Most of Mr. Morgan's field work was on the West Coast of the South Island, to which district he was detailed shortly after his appointment to the staff of the Geological Survey in May 1905. He assisted in the examination of the Hokitika Quadrangle, and later was in charge of the survey of the Mikonui, Greymouth, and Buller-Mokihinui subdivisions. He did a large part of the field-work himself, though assisted for longer or shorter periods by A. R. Andrew, J. M. Finlayson, R. A. Farquharson and J. A. Bartrum, men not unknown in the geological world, who did their first field-work under Mr. Morgan. Much of these areas consists of rough mountainous country densely wooded to the snow-line and with few roads. Its exploration was not accomplished without difficulty and hardship.

The chief economic result of these explorations was the mapping of the Greymouth and Westport districts, which together contain nearly all the high grade coals of New Zealand. The structure of the coalfields was worked out in detail, the succession of beds established, and the amount of coal estimated. Mr. Morgan showed that two sets of coal-measures existed on the West Coast, he added to Hector's and McKay's work on the alluvial gold deposits, and described the petroleum seepages at Kotuku. Of great theoretical interest was the fact that he proved that the structure of the southern Alps was not as had been suggested by Hochstetter, and till then accepted by all New Zealand geologists. In addition he showed that the Hawks Crag Breccia was not of glacial origin, and that the Tertiary sequence was broken by erosion intervals.

During the last two seasons in the Buller-Mokihinui Subdivision Mr. Morgan's duties as Director of the Geological Survey considerably hampered his field-work. He did not again attempt to carry out an extended areal survey personally, and, except for brief periods and chiefly in the Taranaki district, did no systematic exploration. Such time as he could spare from administrative and office work was spent in preliminary visits to districts later to be surveyed, in examining quarries, mines, and desposits of economic value, and generally in acting as adviser to the Government in all geological matters. For this his wide experience and sound knowledge of geology in all its branches peculiarly fitted him.

Only a few of the results of this later work can here be mentioned. Mr. Morgan's comprehensive knowledge of the minerals and rocks of economic value occurring in New Zealand is shown by his numerous papers and reports on these materials,



**PERCY GATES MORGAN**



and especially by his as yet unpublished *Minerals and Mineral Substances of New Zealand*. He made a special study of the coal-fields and oilfields of the Dominion, and wrote much about them. His early association with Waihi caused the vast amount of work and intensive study entailed in the preparation of the bulletin on the Waihi district to be a labour of love.

Apart from the economic side his extensive knowledge of New Zealand geology is shown in his report on the limestones of New Zealand and in the notes accompanying his geological map of New Zealand. He was particularly interested in the Tertiary rocks, which his extended experience led him to believe were broken by numerous unconformities, some merely local. Mr. Morgan's early work in North Westland made him interested in glaciation and structural geology, subjects to which, in his later years, he devoted considerable study.

Though not a specialist, with the limitations so often seen in a specialist, all his work was characterized by thoroughness. His care and accuracy in the field were exceptional, and were applied with unwearying patience; before writing, the literature on any subject was methodically summarized; and his reports when written were revised again and again. His published work has the unquestioning confidence of those who know how conscientiously it was prepared. He valued geological intuition highly, but strove to make his own and his officers' reports independent of it by basing results and deductions only on the vast array of facts collected. He strongly held that geology in New Zealand and the future mineral industries dependent thereon must be based on the sure foundation of accurate knowledge. To this end he carried out much spade work that would yield no immediate return; the extensive library he built up, the palaeontological research begun under his directorship, and his stout resistance to his officers being diverted from the areal survey he regarded as of prime importance, resulted from this belief and from his high ideals of scientific work.

On account of his retiring disposition, and reluctance towards verbal expression, Mr. Morgan did not appeal at once as do many with far less than his solidity to back their confidence; but if any paper or work were submitted to him for criticism, he spared no trouble in examining it, and in making notes on what weaknesses there might be and how these might best be remedied; at the same time he was ungrudging in his appreciation of good sound work. The death of Mr. Morgan, on 26th November, 1927, leaves a blank it will be hard to fill; it is a distinct loss not only to the work of geology in New Zealand, but to the workers in geology also.

J. HENDERSON.



## APPENDIX.



NEW ZEALAND INSTITUTE ACT, 1908.  
1908, No. 130.

AN ACT to consolidate certain Enactments of the General Assembly relating to the New Zealand Institute.

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. (1.) The Short Title of this Act is the New Zealand Institute Act, 1908.

(2.) This Act is a consolidation of the enactments mentioned in the Schedule hereto, and with respect to those enactments the following provisions shall apply:—

- (a) The Institute and Board respectively constituted under those enactments, and subsisting on the coming into operation of this Act, shall be deemed to be the same Institute and Board respectively constituted under this Act without any change of constitution or corporate entity or otherwise; and the members thereof in office on the coming into operation of this Act shall continue in office until their successors under this Act come into office.
- (b) All Orders in Council, regulations, appointments, societies incorporated with the Institute, and generally all acts of authority which originated under the said enactments or any enactment thereby repealed, and are subsisting or in force on the coming into operation of this Act, shall enure for the purposes of this Act as fully and effectually as if they had originated under the corresponding provisions of this Act, and accordingly shall, where necessary, be deemed to have so originated.
- (c) All property vested in the Board constituted as aforesaid shall be deemed to be vested in the Board established and recognised by this Act.
- (d.) All matters and proceedings commenced under the said enactments, and pending or in progress on the coming into operation of this Act, may be continued, completed, and enforced under this Act.

2. (1.) The body now known as the New Zealand Institute (hereinafter referred to as “the Institute”) shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke’s Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as heretofore have been or may hereafter be incorporated therewith in accordance with regulations heretofore made or hereafter to be made by the Board of Governors.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

3. The control and management of the Institute shall be vested in a Board of Governors (hereinafter referred to as "the Board"), constituted as follows:—

The Governor:

The Minister of Internal Affairs:

Four members to be appointed by the Governor in Council, of whom two shall be appointed during the month of December in every year.

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

4. (1.) Of the members appointed by the Governor in Council, the two members longest in office without reappointment shall retire annually on the appointment of their successors.

(2.) Subject to the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

5. The Board shall be a body corporate by the name of the "New Zealand Institute," and by that name shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

6. (1.) The Board shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) The Board shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3. The Board shall have power from time to time to make regulations under which societies may become incorporated with the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with; and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property from time to time vested in it or acquired by it; and shall make regulations for the management of the same, and for the encouragement of research by the members of the Institute; and in all matters, specified or unspecified shall have power to act for and on behalf of the Institute.

7. (1.) Any casual vacancy in the Board, howsoever caused, shall be filled within three months by the society or authority that ap-

pointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board.

(2.) Any person appointed to fill a casual vacancy shall only hold office for such period as his predecessor would have held office under this Act.

8. (1.) Annual meetings of the Board shall be held in the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

9. The Board may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in New Zealand by any means that may appear desirable.

10. The Minister of Finance shall from time to time, without further appropriation than this Act, pay to the Board the sum of five hundred pounds in each financial year, to be applied in or towards payment of the general current expenses of the Institute.

11. Forthwith upon the making of any regulations or the publication of any Transactions, the Board shall transmit a copy thereof to the Minister of Internal Affairs, who shall lay the same before Parliament if sitting, or if not, then within twenty days after the commencement of the next ensuing session thereof.

#### SCHEDULE.

##### *Enactments consolidated.*

1903, No. 48. The New Zealand Institute Act, 1903.

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#### NEW ZEALAND INSTITUTE AMENDMENT ACT, 1920.

1920, No. 3.

AN ACT to amend the New Zealand Institute Act, 1908.

[30th July, 1920.]

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. This Act may be cited as the New Zealand Institute Amendment Act, 1920, and shall be read together with and deemed part of the New Zealand Institute Act, 1908.

2. Section ten of the New Zealand Institute Act, 1908, is hereby amended by omitting the words "five hundred pounds," and substituting the words "one thousand pounds."

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#### FROM THE FINANCE ACT, 1925, No. 51.

7. (1.) The Minister of Finance shall, without further authority than this section, pay to the Board of Governors of the New Zealand

Institute the sum of one thousand five hundred pounds in each financial year, commencing with the year beginning on the first day of April, nineteen hundred and twenty-five, to be applied in or towards payment of the general expenses of the Institute.

(2.) This section is in substitution for section ten of the New Zealand Institute Act, 1908, and that section and the New Zealand Institute Amendment Act, 1920, are hereby repealed.

### REGULATIONS.

THE following are the regulations of the New Zealand Institute under the Act of 1903:—\*

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by the New Zealand Institute Act, 1903.

### INCORPORATION OF SOCIETIES.

1. No society shall be incorporated with the Institute under the provisions of the New Zealand Institute Act, 1903, unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

### PUBLICATIONS.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

(a.) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

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\**New Zealand Gazette*, 14th July, 1904.

- (2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."
- (b.) The Board of Governors shall determine what papers are to be published.
  - (c.) Papers not recommended for publication may be returned to their authors if so desired.
  - (d.) All papers sent in for publication must be legibly written, typewritten, or printed.
  - (e.) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.
  - (f.) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

#### MANAGEMENT OF THE PROPERTY OF THE INSTITUTE.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

#### HONORARY MEMBERS.

8. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

9. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary of the Institute, may nominate for election as honorary member one person.

10. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

*Additional Regulation adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette of 28th May, 1925.*

10A. Vacancies in the list of honorary members shall be announced at each annual meeting of the Board of Governors, and such announcement be communicated as early as possible to each incorporated

society, and each such society shall on or before the 1st December nominate one person for each vacancy as honorary member, and the election shall take place at the next annual meeting of the Board of Governors.

#### GENERAL REGULATIONS.

11. Subject to the New Zealand Institute Act, 1908, and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

12. Upon application signed by the President and countersigned by the Secretary of any Society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

13. In voting on any subject the President is to have a deliberate as well as a casting vote.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than 30th November.

The following additional regulations, and amendment to regulations, were adopted at a general meeting of the Board of Governors of the New Zealand Institute, held at Wellington on the 30th January, 1918, and at Christchurch on the 3rd February, 1919. (See *New Zealand Gazette*, No. 110, 4th September, 1919.)

#### REGULATIONS GOVERNING THE FELLOWSHIP OF THE INSTITUTE.

20. The Fellowship of the New Zealand Institute shall be an honorary distinction for the life of the holder.

21. The Original Fellows shall be twenty in number, and shall include the past Presidents and the Hutton and Hector Medallists who have held their distinctions and positions prior to 3rd February, 1919, and who at that date are members of the Institute. The remaining Original Fellows shall be nominated as provided for in Regula-

tion 26 (a), and shall be elected by the said past Presidents and Hector and Hutton Medallists.

22. The total number of Fellows at any time shall not be more than forty.

23. After the appointment and election of the Original Fellows, as provided in Regulation 21, not more than four Fellows shall be elected in any one year. The number to be elected in any year shall be decided by the Board of Governors at the previous annual meeting.

24. The Fellowship shall be given for research or distinction in science.

25. No person shall be nominated or elected as Fellow unless he has been a member of the N.Z. Institute for three years immediately preceding his nomination, or for five years at any period preceding his nomination.

26. After the appointment and election of the Original Fellows as provided in Regulation 21 there shall be held an annual election of Fellows at such time as the Board of Governors shall appoint. Such election shall be determined as follows:—

- (a.) Each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin may nominate not more than twice as many persons as there are vacancies, and each of the other incorporated societies may nominate as many persons as there are vacancies. Each nomination must be accompanied by a statement of the qualifications of the candidate for Fellowship.
- (b.) Out of the persons so nominated the Fellows resident in New Zealand shall select twice as many persons as there are vacancies, if so many be nominated.
- (c.) The names of the nominees shall be submitted to the Fellows at least six months, and the names selected by them submitted to the Governors at least three months, before the date fixed for the annual meeting of the Board of Governors at which the election is to take place.
- (d.) The election shall be made by the Board of Governors at the annual meeting from the persons selected by the Fellows.
- (e.) The methods of selection in subclause (b) and of the election in sub-clause (d) shall be determined by the Board of Governors.
- (f.) The official abbreviation of the title "Fellow of the New Zealand Institute" shall be "F.N.Z.Inst."

*Additional Regulation adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette of 28th May, 1925.*

26A. The consent of the candidate must be obtained in writing. The information regarding each candidate shall be condensed to one foolscap sheet of typewritten matter.

When a candidate is proposed by more than one society it shall be sufficient to circulate to voters the information supplied by one society.

Subsection (e) shall be rescinded, and the following inserted:—  
*Method of Selection in Subclause (b) and of Election in Subclause (d)*

Names of Candidates, in Alphabetical Order.	X
APPLE, CHARLES     ....	
BROWN, JOHN        ....	
SMITH, JAMES        ....	

There are                      vacancies to be filled. Place a cross in the column marked X against the name of each candidate for whom you wish to vote. The vote will be invalid if—

- (a.) More than the required number is voted for on the paper:
- (b.) The voter signs the voting-paper:
- (c.) The voting-paper is not returned on the date announced.

#### AMENDMENT TO REGULATIONS.

Regulation 5 (a) of the regulations published in the *New Zealand Gazette* on the 14th July, 1904, is hereby amended to read:—

“(a.) The publications of the Institute shall consist of—

“ (1.) Such current abstract of the proceedings of the societies for the time being incorporated with the Institute as the Board of Governors deems desirable;

“ (2.) And of transactions comprising papers read before the incorporated societies or any general meeting of the New Zealand Institute (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time for special reasons in each case determine to publish, to be intituled *Transactions of the New Zealand Institute.*”

#### ADDITIONAL REGULATIONS.

The following additional regulations, made at various times by the Board of Governors under the New Zealand Institute Act, 1908, were adopted at a general meeting of the Board held on the 30th January, 1923, and published in the *New Zealand Gazette* of the 28th May, 1925.

#### BOARD OF GOVERNORS.

Members of the Board of Governors shall not hold any paid office under the Board.

#### GENERAL REGULATIONS.

The President shall be *ex officio* a member of all committees.

The Hon. Editor shall be convener of the Publications Committee.

The seal of the old Institute bearing the date of establishment as 1867 shall be adopted as the seal of the New Zealand Institute reconstituted by the New Zealand Institute Act, 1903, and continued by the New Zealand Institute Act, 1908.

An abstract of all business transacted at each meeting of the Standing Committee shall be prepared and communicated to all members of the Board after each meeting.

The quorum of the Standing Committee meetings shall be four.

## ENDOWMENT FUND.

A fund to be called an "Endowment Fund" shall be set up, the interest on which for any year may be spent for purposes of the Institute, but the capital may not be spent.

All interest accruing from moneys deposited in the Institute's General Account in the Post Office Savings-bank shall be credited to the Endowment Fund, unless otherwise allocated by the Board at the annual meeting at which the amount of the annual interest is reported.

## TRUST ACCOUNTS.

Trust-moneys — namely, the Carter, Hector, Hutton, and Hamilton Funds—shall, when deposited in the Post Office Savings-bank, be placed in separate accounts for each trust.

## REGULATIONS FOR ADMINISTERING THE GOVERNMENT RESEARCH GRANT.\*

ALL grants shall be subject to the following conditions, and each grantee shall be duly informed of these conditions:—

1. All instruments, specimens, objects, or materials of permanent value, whether purchased or obtained out of or by means of the grant, or supplied from among those at the disposal of the Institute, are to be regarded, unless the Research Grants Committee decide otherwise, as the property of the Institute, and are to be returned by the grantee, for disposal according to the orders of the committee, at the conclusion of his research, or at such other time as the committee may determine.

2. Every one receiving a grant shall furnish to the Research Grants Committee, on or before the 1st January following upon the allotment of the grant, a report (or, if the object of the grant be not attained, an interim report, to be renewed at the same date in each subsequent year until a final report can be furnished or the committee dispense with further reports), containing (a) a brief statement showing the results arrived at or the stage which the inquiry has reached; (b) a general statement of the expenditure incurred, accompanied, as far as is possible, with vouchers; (c) a list of the instruments, specimens, objects, or materials purchased or obtained out of the grant, or supplied by the committee, which are at present in his possession; and (d) reference to any transactions, journals, or other publications in which results of the research have been printed. In the event of the grantee failing to send in within three months of the said 1st January a report satisfactory to the committee he may be required, on resolution of the Board of Governors, to return the whole of the sum allotted to him.

3. Where a grant is made to two or more persons acting as a committee for the purpose of carrying out some research, one member

\*In addition to these regulations the Standing Committee is also bound by certain resolutions which appear on page 536 of volume 49, *Trans. N.Z. Inst.*, and which grantees are also bound to observe.

of the said committee shall assume the responsibility of furnishing the report and receiving and disbursing the money.

4. Papers in which results are published that have been obtained through aid furnished by the Government grant should contain an acknowledgment of that fact.

5. Every grantee shall, before any of the grant is paid to him, be required to sign an engagement that he is prepared to carry out the general conditions applicable to all grants, as well as any conditions which may be attached to his particular grant.

6. In cases where specimens or preparations of permanent value are obtained through a grant the committee shall, as far as possible, direct that such specimens shall be deposited in a museum or University college within the province where the specimens or material were obtained, or in which the grantee has worked. The acknowledgment of the receipt of the specimens by such institution shall fully satisfy the claims of the Institute.

7. In cases where, after completion of a research, the committee directs that any instrument or apparatus obtained by means of the grant shall be deposited in an institution of higher learning, such deposit shall be subject to an annual report from the institution in question as to the condition of the instrument or apparatus, and as to the use that has been made of it.

*Additional Regulations adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette of  
28th May, 1925.*

8. Grants shall be given preferentially to investigations which appear to have an economic bearing; purely scientific investigations to be by no means excluded. When the research is one that leads to a direct economic advance the Government shall reserve to itself the right of patenting the discovery and of rewarding the discoverer, but it is to be understood that grants from the research-grant vote are not in the nature of a reward or a prize, but for out-of-pocket expenses incurred by the research worker, including salary or endowment of assistant, but not salary for the grantee himself. Plants, books, apparatus, chemicals, &c., purchased for applicants are to remain the property of the Institute, and eventually to form a loan collection of apparatus in the manner now practised by the Royal Society of London.

First method of initiating researches: Applications shall be invited for grants in aid of research to be specified by applicants.

Second method of initiating researches: The Governors of the Institute shall suggest from time to time subjects the investigation of which is desirable, and ask capable investigators to undertake such researches, the Institute paying for apparatus, material, and working-expenses, including assistance.

9. All applications for grants shall come through some incorporated society.

10. In the case of a refusal to recommend a grant, the Standing Committee shall not give any reasons for its refusal, unless such reason is stated in the minutes of the Standing Committee's meeting.

## RESEARCH GRANTS MADE FOR THE PERIOD ENDING DECEMBER, 1926.

Through the Auckland Institute:

W. F. Short, £75 (additional) for research on constituents of Essential Oils.

Through the Philosophical Institute of Canterbury:

Dr. F. W. Hilgendorf £50, for calculating machine for co-ordinating agricultural experiments.

Mr. G. Jobberns, £50 for correlating shore platforms of the N.E. Coast of the South Island.

Mr. H. F. Skey £175 (additional), to carry on Capt. Isitt's research on Upper Air Currents.

Through the Otago Institute:

Dr. J. Malcolm £150 (additional), for research on Food Value of New Zealand Fish.

Mr. F. H. McDowall £20 (additonal), for research on the oil of the ngaio.

Dr. J. K. H. Inglis £20 (additional), for research on essential oils.

Through the Nelson Institute:

Professor T. H. Easterfield £100 (additional), for research on cool storage of fruit.

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## BOARD OF SCIENCE AND ART.

FROM THE SCIENCE AND ART ACT, 1913, No. 22.

8. (1.) There shall be a Board styled "The Board of Science and Art," consisting of—

The Minister of Internal Affairs.

The Director of the Dominion Museum:

*The President of the New Zealand Institute:—*

Five persons to be appointed by the Governor-General in Council, each of whom shall hold office for three years from the date of his appointment.

(2.) The Board shall sit in the City of Wellington at such times and places as shall be appointed from time to time by the Minister.

(3.) Three of the members shall form a quorum.

(4.) At all meetings of the Board the Minister, if present, shall be the Chairman, and in his absence some member of the Board appointed by him in writing shall be Chairman.

(5.) The Chairman shall have a deliberate vote, and in all cases of equality of votes shall have a casting-vote.

(6.) *The President of the New Zealand Institute may appoint in writing a deputy, being a Governor of the New Zealand Institute, to attend and act at any meeting of the Board in his place; and such deputy, while so attending, shall be deemed to be a member of the Board.*

## TONGARIRO NATIONAL PARK BOARD.

FROM THE TONGARIRO NATIONAL PARK ACT, 1922, No. 31.

5. (1.) The park shall be controlled and managed by a Board constituted as hereinafter provided.

(2.) The Board shall be a body corporate under the name of the Tongariro National Park Board, with perpetual succession and a common seal, and shall be capable of holding real and personal property and of doing and suffering all that bodies corporate may lawfully do or suffer.

(3.) The Board shall consist of the following persons:—

(a) The Minister of Lands:

(b.) The paramount chief for the time being of the Ngatitu-wharetoa Tribe of the Native race if that chief is a lineal descendant of Te Heuheu Tukino, the donor of the Native land included in the area of the Tongariro National Park:

(c.) The Mayors of the cities of Auckland and Wellington.

(d.) The Warden of the Park:

(e.) The Under-Secretary of the Department of Lands and Survey:

(f.) The General Manager of the Department of Tourist and Health Resorts:

(g.) The Secretary of the State Forest Service:

(h.) *The President of the New Zealand Institute*

(i.) Not more than four persons to be appointed in that behalf by the Governor-General in Council.

\* \* \* \* \*

8. (1.) The first ordinary meeting of the Board shall be held at such time and place as the Minister appoints, and subsequent ordinary meetings shall be held at such times and places as the Board appoints.

(2.) Special meetings of the Board may be called at any time by the Chairman, and he shall call one whenever any three members so request in writing.

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FROM THE TONGARIRO NATIONAL PARK AMENDMENT ACT, 1927, No. 46.

Subsection three of section five of the principal Act is hereby amended by repealing paragraph (h) thereof, and substituting the following paragraph:—

“(h) One member to be appointed by the Board of Governors of the New Zealand Institute, who shall hold office for three years from the date of his appointment, or until the appointment of his successor, and shall be eligible for reappointment.”

## THE HUTTON MEMORIAL MEDAL AND RESEARCH FUND.

## DECLARATION OF TRUST.

THIS deed, made the fifteenth day of February, one thousand nine hundred and nine (1909), between the New Zealand Institute of the one part, and the Public Trustee of the other part: Whereas the New Zealand Institute is possessed of a fund consisting now of the sum of five hundred and fifty-five pounds one shilling (£555 1s.), held for the purposes of the Hutton Memorial Medal and Research Fund on the terms of the rules and regulations made by the Governors of the said Institute, a copy whereof is hereto annexed: And whereas the said money has been transferred to the Public Trustee for the purposes of investment, and the Public Trustee now holds the same for such purposes, and it is expedient to declare the trusts upon which the same is held by the Public Trustee:

Now this deed witnesseth that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purposes upon trust from time to time to invest the same upon such securities as are lawful for the the Public Trustee to invest on, and to hold the principal and income thereof for the purposes set out in the said rules hereto attached.

And it is hereby declared that it shall be lawful for the Public Trustee to pay all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed so to do by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year hereinbefore written.

## RESOLUTIONS OF BOARD OF GOVERNORS.

RESOLVED by the Board of Governors of the New Zealand Institute that—

1. The funds placed in the hands of the Board by the committee of subscribers to the Hutton Memorial Fund be called "The Hutton Memorial Research Fund," in memory of the late Captain Frederick Wollaston Hutton, F.R.S. Such fund shall consist of the moneys subscribed and granted for the purpose of the Hutton Memorial, and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding £100 shall be expended in procuring a bronze medal to be known as "The Hutton Memorial Medal."

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as aforesaid as may be approved of by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund.

5. The Hutton Memorial Medal shall be awarded from time to time by the Board of Governors, in accordance with these regulations, to persons who have made some noticeable contribution in connection with the zoology, botany, or geology of New Zealand.

6. The Board shall make regulations setting out the manner in which the funds shall be administered. Such regulations shall conform to the terms of the trust.

7. The Board of Governors may, in the manner prescribed in the regulations, make grants from time to time from the accrued interest to persons or committees who require assistance in prosecuting researches in the zoology, botany, or geology of New Zealand.

8. There shall be published annually in the *Transactions of the New Zealand Institute* the regulations adopted by the Board as aforesaid, a list of the recipients of the Hutton Memorial Medal, a list of the persons to whom grants have been made during the previous year, and also, where possible, an abstract of researches made by them.

*Resolution regarding Investment of Funds (see Clause 4 above) adopted by Board on 30th January, 1923, and published in New Zealand Gazette of 28th May, 1925.*

That the fund known as the "Hutton Memorial Fund," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

That until the Hutton Memorial Fund reaches the sum of £1,000 not less than 1 per cent. on the capital invested be added each year to the principal.

#### REGULATIONS UNDER WHICH THE HUTTON MEMORIAL MEDAL SHALL BE AWARDED AND THE RESEARCH FUND ADMINISTERED.

1. Unless in exceptional circumstances, the Hutton Memorial Medal shall be awarded not oftener than once in every three years; and in no case shall any medal be awarded unless, in the opinion of the Board, some contribution really deserving of the honour has been made.

2. The medal shall not be awarded for any research published previous to the 31st December, 1906.

3. The research for which the medal is awarded must have a distinct bearing on New Zealand zoology, botany, or geology.

4. The medal shall be awarded only to those who have received the greater part of their education in New Zealand or who have resided in New Zealand for not less than ten years.

5. Whenever possible, the medal shall be presented in some public manner.

6. The Board of Governors may, at any annual meeting, make grants from the accrued interest of the fund to any person, society, or committee for the encouragement of research in New Zealand zoology, botany, or geology.

7. Applications for such grants shall be made to the Board before the 30th September.

8. In making such grants the Board of Governors shall give preference to such persons as are defined in regulation 4.

9. The recipients of such grants shall report to the Board before the 31st December in the year following, showing in a general way how the grant has been expended and what progress has been made with the research.

10. The results of researches aided by grants from the fund shall, where possible, be published in New Zealand.

11. The Board of Governors may from time to time amend or alter the regulations, such amendments or alterations being in all cases in conformity with resolutions 1 to 4.

#### AWARD OF THE HUTTON MEMORIAL MEDAL.

1911. Professor W. B. Benham, D.Sc., F.R.S., University of Otago—For researches in New Zealand zoology.

1914. Dr. L. Cockayne, F.L.S., F.R.S.—For researches in the ecology of New Zealand plants.

1917. Professor P. Marshall, M.A., D.Sc.—For researches in New Zealand geology.

1920. Rev. John E. Holloway, D.Sc.—For researches in New Zealand pteridophytic botany.

1923. J. Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst.—For researches in geology.

1926. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S., F.N.Z.Inst.—For his continuous researches on the Amphipodous Crustacea of the Southern Hemisphere.

#### GRANT FROM THE HUTTON MEMORIAL RESEARCH FUND.

1919. Miss M. K. Mestayer £10, for work on the New Zealand Mollusca.

1923. Professor P. Marshall, M.A., D.Sc., F.N.Z.Inst.—£40, for study of Upper Cretaceous ammonites of New Zealand.

1927. Miss M. K. Mestayer £30, for research on Brachiopoda and Mollusca.

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#### HECTOR MEMORIAL RESEARCH FUND.

##### DECLARATION OF TRUST.

THIS deed, made the thirty-first day of July, one thousand nine hundred and fourteen, between the New Zealand Institute, a body corporate duly incorporated by the New Zealand Institute Act, 1908, of the one part, and the Public Trustee of the other part; Whereas

by a declaration of trust dated the twenty-seventh day of January, one thousand nine hundred and twelve, after reciting that the New Zealand Institute was possessed of a fund consisting of the sum of £1,045 10s. 2d., held for the purposes of the Hector Memorial Research Fund on the terms of the rules and regulations therein mentioned, which said moneys had been handed to the Public Trustee for investment, it was declared (*inter alia*) that the Public Trustee should hold the said moneys and all other moneys which should be handed to him by the said Governors of the Institute for the same purpose upon trust from time to time, to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations in the said deed set forth: And whereas the said rules and regulations have been amended by the Governors of the New Zealand Institute, and as amended are hereinafter set forth: And whereas it is expedient to declare that the said moneys are held by the Public Trustee upon the trusts declared by the said deed of trust and for the purposes set forth in the said rules and regulations as amended as aforesaid.

Now this deed witnesseth and it is hereby declared that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purpose upon trust from time to time to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations hereinafter set forth:

And it is hereby declared that it shall be lawful for the Public Trustee to pay, and he shall pay, all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed to do so by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year first hereinbefore written.

*Rules and Regulations made by the Governors of the New Zealand Institute, in relation to the Hector Memorial Research Fund.*

1. The funds placed in the hands of the Board by the Wellington Hector Memorial Committee shall be called "The Hector Memorial Research Fund," in memory of the late Sir James Hector, K.C.M.G., F.R.S. The object of such fund shall be the encouragement of scientific research in New Zealand, and such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the said Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding one hundred pounds (£100) shall be expended in procuring a bronze medal, to be known as the Hector Memorial Medal.

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as may be approved by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund by providing thereout a prize for the encouragement of such scientific research in New Zealand of such amount as the Board of Governors shall from time to time determine.

5. The Hector Memorial Medal and prize shall be awarded annually by the Board of Governors.

6. The prize and medal shall be awarded by rotation for the following subjects, namely—(1) Botany, (2) chemistry, (3) ethnology, (4) geology, (5) physics (including mathematics and astronomy), (6) zoology (including animal physiology).

In each year the medal and prize shall be awarded to that investigator who, working within the Dominion of New Zealand, shall in the opinion of the Board of Governors have done most towards the advancement of that branch of science to which the medal and prize are in such year allotted.

7. Whenever possible the medal shall be presented in some public manner.

*Resolution regarding Investment of Funds (see Clause 4 above) adopted by Board on 30th January, 1923, and published in New Zealand Gazette of 28th May, 1925.*

That the fund known as the "Hector Memorial Fund," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

#### AWARD OF THE HECTOR MEMORIAL RESEARCH FUND.

- 1912. L. Cockayne, Ph.D., F.L.S., F.R.S.—For researches in New Zealand botany.
- 1913. T. H. Easterfield, M.A., Ph.D.—For researches in chemistry.
- 1914. Elsdon Best—For researches in New Zealand ethnology.
- 1915. P. Marshall, M.A., D.Sc., F.G.S.—For researches in New Zealand geology.
- 1916. Sir Ernest Rutherford, F.R.S.—For researches in physics.
- 1917. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S.—for researches in zoology.
- 1918. T. F. Cheeseman, F.L.S., F.Z.S.—For researches in New Zealand systematic botany.

- 1919. P. W. Robertson—For researches in chemistry.
- 1920. S. Percy Smith—For researches in New Zealand ethnology.
- 1921. R. Speight, M.A., M.Sc., F.G.S.—For work in New Zealand geology.
- 1922. C. Coleridge Farr, D.Sc.—For research in physical science, and more particularly work in connection with the magnetic survey of New Zealand.
- 1923. G. V. Hudson, F.E.S., F.N.Z.Inst.—For researches in New Zealand entomology.
- 1924. D. Petrie, M.A., F.N.Z.Inst.—For researches in New Zealand botany.
- 1925. B. C. Aston, F.I.C., F.N.Z.Inst.—For the investigation of New Zealand chemical problems.
- 1926. H. D. Skinner, B.A.—For research in Ethnology.

#### HAMILTON MEMORIAL FUND.

1. The fund placed in the hands of the Board by the Wellington Philosophical Society shall be called the "Hamilton Memorial Fund" in memory of the late Augustus Hamilton, Esq. Such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The fund shall be vested in the Institute. The Board of Governors of the Institute shall have the control thereof, and shall invest the same in any securities proper for trust-moneys.

3. The memorial shall be a prize, to be called the "Hamilton Memorial Prize," the object of which shall be the encouragement of beginners in pure scientific research in New Zealand.

4. The prize shall be awarded at intervals of not less than three years by the Governors assembled in annual meeting, but in no case shall an award be made unless in the opinion of the Governors some contribution deserving the honour has been made. The first award shall be made at the annual meeting of the Governors in 1923.

5. The prize shall be awarded for original pure scientific research-work, carried out in New Zealand or in the Islands of the South Pacific Ocean, which has been published within the five years preceding the first day of July prior to the annual meeting at which the award is made. Such publication may consist of one or more papers, and shall include the first investigation published by the author. No candidate shall be eligible for the prize who prior to such period of five years has published the result of any scientific investigation.

6. The prize shall consist of money. Until the principal of the fund amounts to £100, one-half of the interest shall be added annually to the principal and the other half shall be applied in payment of the prize. So soon as the said principal amounts to £100 the whole of the interest thereon shall be applied in payment of the prize, in each case after the payment of all expenses necessarily incurred by the Governors in the investment and administration of the said fund and award of the said prize.

7. A candidate for the prize shall send to the Hon. Secretary of the New Zealand Institute, on or before the 30th day of June preceeding the date of the annual meeting at which the award is to be made, an intimation of his candidature, together with at least two copies of each publication on which his application is based.

8. Whenever possible the prize shall be presented in some public manner.

AWARD OF THE HAMILTON MEMORIAL PRIZE.

1923. J. G. Myers, M.Sc.

1926. H. J. Finlay, M.Sc.; J. Marwick, M.A., D.Sc.

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THE CARTER BEQUEST.

EXTRACTS FROM THE WILL OF CHARLES ROOKING CARTER.

THIS is the last will and testament of me, Charles Rooking Carter, of Wellington, in the Colony of New Zealand, gentleman.

I revoke all wills and testamentary dispositions heretofore made by me, and declare this to be my last will and testament.

\* \* \* \* \*

I give to the Colonial Museum in Wellington the large framed photographs of the members of the General Assembly in the House of Representatives in the year 1860, and the framed pencil sketch of the old House of Commons, and the framed invitation-card to the Lord Mayor's dinner.

\* \* \* \* \*

As regards the following books, of which I am the author, and which are now stored in three boxes—namely, (1) "The Life and Recollections of a New Zealand Colonist," (2) "A Historical Sketch of New Zealand Loans," and (3) "Round the World Leisurely"—I direct that my executor shall retain possession of the same for a period of seven years, commencing from the date of my death, and that at the end of such period my executor shall place the same in the hands of Messrs. Whitcombe and Tombs (Limited) or some other capable and responsible booksellers in the City of Wellington, for sale, and so that the same shall be sold at such a price as will yield to my estate not less than six shillings per volume in respect of the first-named and second-named, and two shillings and sixpence in respect of the last-named works; and I further authorize my executor to sell and dispose of the copyright or right to reprint such works; and I direct that the moneys to be derived from the sale of such works and the privileges connected therewith shall be added to the sum provided for the purchase of a telescope as hereinafter mentioned.

I direct my executor to subscribe the sum of fifty pounds towards the erection of a suitable brick room in which to house the priceless collection of books on New Zealand some time since given by me to the Colonial Museum and the New Zealand Institute.

I give and devise unto the Public Trustee appointed under and in pursuance of an Act of the General Assembly of New Zealand intituled the Public Trust Office Act, 1894 (hereinafter called "my trustee"), all the rest, residue, and remainder of my property whatsoever and wheresoever situate, both real and personal, and whether in possession, reversion, expectancy, or remainder, upon trust, as to my freehold property at East Taratahi, containing by admeasurement two thousand one hundred and seventy-two acres, and being and comprising the whole of the land included in certificate of title, volume 51, folio 79, of the books of the District Land Registrar for the Registration District of Wellington, (save and except such part of the said land, being portion of the section numbered 117 in the Taratahi Plain Block, as is hereinafter devised to my trustee for the purposes hereinafter appearing), and direct that my trustee shall stand possessed of the same lands upon trust, to let and manage the same, and to pay and apply the rents and annual income in manner following, namely:—

\* \* \* \* \*

And as to all the residue and remainder (if any) of the said net proceeds of the sale, conversion, and getting-in of my estate as aforesaid, my trustee shall transfer the same to the Governors for the time being of the New Zealand Institute at Wellington, to form the nucleus of a fund for the erection in or near Wellington aforesaid, and the endowment of a Professor and staff, of an Astronomic Observatory fitted with telescope and other suitable instruments for the public use and benefit of the colony, and in the hope that such fund may be augmented by gifts from private donors, and that the Observatory may be subsidized by the Colonial Government; and without imposing any duty or obligation in regard thereto I would indicate my wish that the telescope may be obtained from the factory of Sir H. Grubb, in Dublin, Ireland.

\* \* \* \* \*

*Resolution regarding Investment of Funds (see Clause 4 above), adopted by Board on 30th January, 1923, and published in the New Zealand Gazette, of 28th May, 1925.*

That the fund known as the "Carter Bequest," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

# NEW ZEALAND INSTITUTE, 1927.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND UNDER THE NEW ZEALAND INSTITUTE ACT, 1903, AND CONTINUED BY THE NEW ZEALAND INSTITUTE ACT, 1908.

## BOARD OF GOVERNORS.

EX OFFICIO.

His Excellency the Governor-General.

The Hon. the Minister of Internal Affairs.

## NOMINATED BY THE GOVERNMENT.

Dr. Charles Chilton, M.A., F.L.S., C.M.Z.S., F.N.Z.Inst. (reappointed December, 1926); Dr. Leonard Cockayne, F.R.S., F.L.S., F.N.Z.Inst. (reappointed December, 1926). Mr B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst. (reappointed December, 1925); Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst. (reappointed December, 1925).

## ELECTED BY AFFILIATED SOCIETIES, 1925.

Wellington Philosophical Society	.....	{	Mr. G. V. Hudson, F.E.S., F.N.Z.Inst. Professor H. B. Kirk, M.A., F.N.Z.Inst.
Auckland Institute	.....	{	Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst. Professor F. P. Worley, D.Sc.
Philosophical Institute of Canterbury	.....	{	Professor C. Coleridge Farr, D.Sc., F.P.S.L., F.N.Z.Inst. Mr. A. M. Wright, A.I.C., F.C.S.
Otago Institute	.....	{	Hon. G. M. Thomson, F.L.S., F.N.Z.Inst., M.L.C. Professor J. Park, F.G.S., F.N.Z.Inst.
Hawke's Bay Philosophical Institute	.....		Mr. H. Hill, B.A., F.G.S.
Nelson Institute	.....		Professor T. H. Easterfield, M.A., Ph.D., F.I.C., F.N.Z.- Inst.
Manawatu Philosophical Society	.....		Mr. M. A. Elliott.

## OFFICERS FOR THE YEAR 1927.

PRESIDENT: Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst.

HON. TREASURER: Mr. M. A. Elliott.

HON. EDITOR: Mr. Johannes C. Andersen, F.N.Z.Inst.

HON. LIBRARIAN: Professor D. M. Y. Somerville, M.A., D.Sc.,  
F.R.S.E., F.N.Z.Inst.HON. RETURNING OFFICER: Professor H. W. Segar, M.A., Ph.D.,  
F.N.Z.Inst.

HON. SECRETARY: P. Marshall, D.Sc., M.A., F.G.S., F.N.Z.Inst.

## AFFILIATED SOCIETIES, 1926-27.

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Wellington Philosophical Society      ....	Mr. W. J. Phillipps, Dominion Museum, Wellington	10th June, 1868.
Auckland Institute      ....	Mr. G. Archey, Auckland Institute and Museum, Auckland	10th June, 1868.
Philosophical Institute of Canterbury      ....	Mr. G. Jobberns, Training College, Christchurch.	22nd October, 1868.
Otago Institute      ....	Rev. Dr. J. Holloway, Otago University, Dunedin.	18th October, 1869.
Hawkes Bay Philosophical Institute      ....	Mr. C. F. H. Pollock, P. O. Box 301, Napier.	31st March, 1875.
Nelson Institute      ....	Mrs. Margaret Graham, Nelson	20th December, 1883
Manawatu Philosophical Society      ....	Mr. J. S. Hornblow, Young's Buildings, Broadway, Palmerston North	6th January, 1905.

## FORMER MANAGER AND EDITOR.

[UNDER THE NEW ZEALAND INSTITUTE ACT, 1867.]

1867-1903.—Hector, Sir James, M.D., K.C.M.G., F.R.S.

# PAST PRESIDENTS.

- 1903-4.—Hutton, Captain Frederick Wollaston, F.R.S.  
 1905-6.—Hector, Sir James, M.D., K.C.M.G., F.R.S.  
 1907-8.—Thomson, George Malcolm, F.L.S.  
 1909-10.—Hamilton, A.  
 1911-12.—Cheeseman, T. F., F.L.S., F.Z.S.  
 1913-14.—Chilton, C., M.A., D.Sc., LL.D., F.L.S., C.M.Z.S.  
 1915.—Petrie, D., M.A., Ph.D.  
 1916-17.—Benham, W. B., M.A., D.Sc., F.Z.S., F.R.S.  
 1918-19.—Cockayne, L., Ph.D., F.R.S., F.L.S., F.N.Z.Inst.  
 1920-21.—Easterfield, T. H., M.A., Ph.D., F.N.Z.Inst.  
 1922-23.—Kirk, H. B., M.A., F.N.Z.Inst.  
 1924-25.—Dr. P. Marshall, M.A., F.G.S., F.N.Z.Inst.

## HONORARY MEMBERS.

	Elected
Armstrong, Professor H. E., F.R.S., Ph.D., LL.D. Professor Emeritus City and Guilds of London Institute, 55 Granville Park, Lewisham, London, S.E.	1927
Bragg, Professor W. H., F.R.S., Royal Institution, 21 Albemarle St., London, W.1	1923
Chree, Charles, M.A., D.Sc., LL.D., F.R.S., Kew Observatory, London	1924
Curie, Madame Marie, Institut du Radium, Laboratoire Curie, 1 Rue Pierre-Curie, Paris (5e)	1927
David, Professor T. Edgeworth, F.R.S., C.M.G., Sydney University	1904
Davis, Professor W. Morris, Museum, Cambridge, Mass., U.S.A.	1913
Diels, Professor L., Ph.D., University of Berlin, Botanisches Museum, Berlin	1907
Einstein, Professor Albert, University of Berlin, Germany	1924
Fraser, Sir J. G., D.C.L., Trinity College, Cambridge	1920
Goebel, Professor Dr. Carl von, University of Munich	1901
Gregory, Professor J. W., D.Sc., F.R.S., F.G.S., 4 Park Quadrant, Glasgow W.	1920
Haddon, Dr. A. C., F.R.S., 3 Cranmer Road, Cambridge	1925
Hall, Sir A. D., M.A., K.C.B., F.R.S., Ministry of Agriculture, London	1920
Jaggard, Dr. T. A., Director of Volcanological Observatory, Volcano House, P.O. Hawaii	1927
Liversidge, Professor A., M.A., F.R.S., Fieldhead, Coombe Warren, Kingston Hill, England	1890
Lotsy, Dr. J. P., Velp, near Arnhem, Holland	
Mawson, Sir Douglas, B.E., D.Sc., The University, Box 498, Adelaide	1920
Mellor, Joseph William, D.Sc. (N.Z.), Sandon House, Regent Street, Stoke-on-Trent, England	1919
Meyrick, E., B.A., F.R.S., Thornhanger, Marlborough, Wilts	1907
Mortensen, Theodor, Ph.D., Director of the Dept. of Invertebrates of the Zoological Museum, Copenhagen	1927
Rutherford, Professor Sir E., D.Sc., F.R.S., F.N.Z.Inst., Newnham Cottage, Queen's Road, Cambridge, England	1904
Sars, Professor G. O., University of Christiania, Norway	1902
Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Wit- combe, Gloucester, England	1894
Woods, Henry, M.A., F.R.S., F.G.S., Sedgwick Museum, Cambridge	1920

## FORMER HONORARY MEMBERS.

	Elected		Elected
Agardh, Dr. J. G. ....	1900	Hemsley, Dr. W. Botting, F.R.S., Kew Lodge, St. Peter's Road, Broadstairs, Kent, England ....	1913
Agassiz, Professor Louis ....	1870	Hochstetter, Dr. Ferdinand von	1870
Arber, E. A. Newell, M.A., Sc.D., F.G.S., F.L.S. ....	1914	Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., O.M. ....	1870
Avebury, Lord, P.C., F.R.S. ....	1900	Howes, G. B., LL.D., F.R.S. ....	1901
Baird, Professor Spencer F. ....	1877	Huxley, Thomas H., LL.D., F.R.S. ....	1872
Balfour, Professor I. Bayley, F.R.S. ....	1914	Klotz, Professor Otto J. ....	1903
Bateson, Professor W., F.R.S. ....	1915	Langley, S. P. ....	1896
Beddard, F. E., D.Sc., F.R.S., Zoological Society, London ....	1906	Lindsay, W. Lauder, M.D., F.R.S.E. ....	1871
Beneden, Professor J. P. van ....	1888	Lydekker, Richard, F.R.S. ....	1896
Berggren, Dr. S. ....	1876	Lyell, Sir Charles, Bart., D.C.L., F.R.S. ....	1873
Bowen, Sir George Ferguson, G.C.M.G. ....	1873	Massart, Professor Jean ....	1916
Brady, G. S., D.Sc., F.R.S. ....	1906	McCoy, Professor Sir F., K.C.M.G., D.Sc., F.R.S. ....	1888
Bruce, Dr. W. S. ....	1910	McLachlan, Robert, F.L.S. ....	1874
Carpenter, Dr. W. B., C.B., F.R.S. ....	1883	Massee, George, F.L.S., F.R.M.S.	1900
Clarke, Rev. W. B., M.A., F.R.S.	1876	Milne, J., F.R.S. ....	1906
Codrington, Rev. R. H., D.D. ....	1894	Mitten, William, F.R.S. ....	1895
Darwin, Charles, M.A., F.R.S. ....	1871	The Most Noble the Marquis of Normanby, G.C.M.G. ....	1880
Darwin, Sir George, F.R.S. ....	1909	Mueller, Ferdinand von, M.D., F.R.S., C.M.G. ....	1870
Davis, J. W., F.G.S., F.L.S. ....	1891	Müller, Professor Max, F.R.S. ....	1878
Dendy, Dr. A., F.R.S., King's College, University of London, England ....	1907	Newton, Alfred, F.R.S. ....	1874
Drury, Captain Byron, R.N. ....	1870	Nordstedt, Professor Otto, Ph.D.	1890
Ellery, Robert L. J., F.R.S. ....	1883	Owen, Professor Richard, F.R.S.	1870
Etheridge, Professor R., F.R.S. ....	1876	Pickard - Cambridge, Rev. O., M.A., F.R.S., C.M.Z.S. ....	1873
Ettingshausen, Baron von ....	1888	Richards, Rear-Admiral G. H. ....	1870
Eve, H. W., M.A. ....	1901	Riley, Professor C. V. ....	1890
Filhol, Dr. H. ....	1875	Rolleston, Professor G., M.D., F.R.S. ....	1875
Finsch, Professor Otto, Ph.D. ....	1870	Sclater, P. L., M.A., Ph.D., F.R.S.	1875
Flower, Professor W. H., F.R.S.	1870	Sharp, Dr. D. ....	1877
Garrod, Professor A. H., F.R.S.	1878	Sharp, Richard Bowdler, M.A., F.R.S. ....	1885
Goodale, Professor G. L., M.D., LL.D. ....	1891	Stebbing, Rev. T. R. R., F.R.S.	1907
Gray, J. E., Ph.D., F.R.S. ....	1871	Stokes, Vice-Admiral J. L. ....	1872
Gray, Professor Asa ....	1885	Tenison-Woods, Rev. J. E., F.L.S.	1878
Grey, Sir George, K.C.B. ....	1872	Thomson, Professor Wyville, F.R.S. ....	1874
Günther, A., M.D., M.A., Ph.D., F.R.S. ....	1873	Thomson, Sir William, F.R.S. ....	1883
Haswell, Professor W. A., F.R.S., Mimihau, Woollahra Point, Sydney ....	1914	Wallace, Sir A. R., F.R.S., O.M.	1885
Hedley, Charles, F.L.S., ....	1924	Weld, Frederick A., C.M.G. ....	1877

# FELLOWS OF THE NEW ZEALAND INSTITUTE.

## ORIGINAL FELLOWS.

(See *New Zealand Gazette*, 20th November, 1919.)

- †Aston, Bernard Cracroft, F.I.C., F.C.S.
- \*†Benham, Professor William Blaxland, M.A., D.Sc., F.R.S., F.Z.S.
- †Best, Elsdon.
- \*†Cheeseman, Thomas Frederick, F.L.S., F.Z.S. §
- \*†‡Chilton, Professor Charles, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., C.M.Z.S.
- \*†‡Cockayne, Leonard, Ph.D., F.R.S., F.L.S.
- †Easterfield, Professor Thomas Hill, M.A., Ph.D., F.I.C., F.C.S.
- †Farr, Professor Clinton Coleridge, D.Sc., F.P.S.L.
- Hogben, George, C.M.G., M.A., F.G.S. §
- †Hudson, George Vernon, F.E.S.
- Kirk, Professor Harry Borrer, M.A.
- †‡Marshall, Patrick, M.A., D.Sc., F.G.S., F.R.G.S., F.E.S.
- \*†Petrie, Donald, M.A., Ph.D. §
- †Rutherford, Sir Ernest, Kt., F.R.S., D.Sc., Ph.D., LL.D.
- Segar, Professor Hugh William, M.A.
- †Smith, Stephenson Percy, F.R.G.S. §
- †Speight, Robert, M.A., M.Sc., F.G.S.
- Thomas, Professor Algernon Phillips Withiel, M.A., F.L.S.
- \*Thomson, Hon. George Malcolm, F.L.S., M.L.C.
- †Thomson, James Allan, M.A., D.Sc., A.O.S.M., F.G.S.

## FELLOWS ELECTED, 1921.

- Cotton, Charles Andrew, D.Sc., A.O.S.M., F.G.S.
- Hilgendorf, Frederick William, B.A., D.Sc.
- †Holloway, Rev. John Ernest, L.Th., D.Sc.
- Park, Professor James, M.Am.Inst.M.E., M.Inst.M.M., F.G.S.

## FELLOWS ELECTED, 1922.

- Laing, Robert Malcolm, M.A., B.Sc.
- Marsden, Ernest, D.Sc., F.R.A.S.
- Morgan, Percy Gates, M.A., F.G.S., A.O.S.M.
- Sommerville, Duncan McLaren Young, M.A., D.Sc., F.R.S.E.

## FELLOWS ELECTED, 1923.

- Williams, Ven. Archdeacon Herbert William, M.A.
- Andersen, Johannes Carl.

## FELLOWS ELECTED, 1924.

- Smith, William Herbert Guthrie.
- Tillyard, Robin John, M.A., D.Sc., Sc.D., F.L.S., F.E.S.

## FELLOWS ELECTED, 1925.

- Brown, Professor J. Macmillan, M.A., LL.D.
- Te Rangi Hiroa (P H. Buck), M.D., Ch.B. (N.Z.).

## FELLOWS ELECTED, 1926.

- Benson, Professor W. N., B.A., D.Sc., F.G.S.
- Maclaurin, J. S., D.Sc., F.C.S.

## FELLOWS ELECTED 1927.

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| Clark, Thomas P., Eskdale.       | Ormond, George, Wairoa.               |
| Cottrell, Horace S., Napier.     | O'Ryan, Wm., Waipiro Bay.             |
| De Castro, F. K., Napier.        | Pallot, Alfred G., Napier.            |
| Dinwiddie, B., Napier.           | Pallot, Mrs. W. J., Napier.           |
| Dinwiddie, Wm., Napier.          | Pollock, C. F. H., Napier.            |
| Dixon, S. J., Hastings.          | Reaney, P. S., Napier.                |
| Duncan, R. J., Napier.           | Ringland, T. H., Napier.              |
| Edgar, Dr. J., Napier.           | Sagar, Mrs. M., Napier.               |
| Edmundson, J. H., Napier.        | Sainsbury, G. O. K., Wairoa.          |
| Fitzgerald, Dr. D. Napier.       | Speight, H., Havelock North.          |
| Ford, A. R., Napier.             | *Smith, H. J., England.               |
| Friend, L. C., Napier.           | Smith, Somerset, Napier.              |
| Fussell, F. N., Napier.          | Steele, H., Napier.                   |
| Geddis, Trevor M., Napier.       | Stout, E. T., Napier.                 |
| Gleadow, J. E., Napier.          | Swansegger, Dr. P., Taradale.         |
| Goldsmith, Miss E., Napier.      | Thorp, Frederick, Napier.             |
| Graham, Henry, Dannevirke.       | Thomas, C. L., Napier.                |
| Greig, Miss V., Wellington.      | Thomson, J. P., Napier.               |
| Gregorie, D. G., Pahiatua.       | Tiffen, G. W., Gisborne.              |
| Guthrie-Smith, W. H., Tutira.    | Vautier, T. P., Napier.               |
| Harding, J. W., Waipukurau.      | Wanklyn, H. A., Napier.               |
| Harding, W. A., Napier.          | Waterworth, Dr. G., Napier.           |
| Harwood, W. G., Napier.          | West, E. S., Napier.                  |
| Harwood, Mrs. W. G., Napier.     | White, Wm., Napier.                   |
| Hay, Leslie, Napier.             | Williams, Frederic W., Napier.        |
| Herrick, E. J., Hastings.        | Williams, Archdeacon H. W., Gisborne. |
| Hetley, Mrs. F. A., Napier.      | Wilson, A. H., Napier.                |
| Hildebrandt, W. H., Napier.      | Wilson, J. G., Hatuma, H.B.           |
| Hill, Bromley, Napier.           | Wilton, T. J., Port Ahuriri.          |
| Hill, Henry, Napier.             |                                       |

NELSON INSTITUTE.

- Bartel, J. G., Collingwood Street.  
 Bett, Dr. F. A., Trafalgar Square.  
 Bruce, James, Britannia Heights.  
 Crequer, V. G., Halifax Street.  
 Cooke, Miss, Examiner Street.  
 Cullen, Father J. J., Catholic Presbytery.  
 Cunningham, G., Wainui Street.  
 Curtis, Dr. K. M., Cawthron Institute.  
 Davies, W. C., Cawthron Institute.  
 Duncan, H. R., Hardy Street.  
 Easterfield, Professor, Cawthron Institute.  
 Field, T. A. H., Rocks Road.  
 Gibbs, F. G., Collingwood Street.  
 Gibbs, Dr. S., Hardy Street.  
 Glasgow, J., Stoke.  
 Gourlay, E. S., Cawthron Institute.  
 Harrison, H., Cawthron Institute.  
 Hunter-Brown, H., Tory Street.  
 Hunter-Brown, Mrs. H., Tory Street.  
 Jamieson, Dr. J. P. S., Hardy Street.  
 Johnston, Dr. W. S., Hardy Street.  
 Kelly, R. H., 26 Hampden Street W.  
 Kemp, G. T., Collingwood Street.  
 Knapp, F. V., Alfred Street.  
 Maddox, F. W., Halifax Street.  
 May, L., Public Works, Trafalgar St.  
 McKay, J. G., Boys' College.  
 Moller, B. H., Collingwood Street.  
 Moncrieff, Captain M. M., The Cliffs.  
 Moncrieff, Mrs. M. M., The Cliffs.  
 Morley, E. L., Waimea Street.  
 Mules, Bishop, Trafalgar Square.  
 Parlane, Miss B., B. Sc., Cawthron Institute.  
 Philpott, A., Cawthron Institute.  
 Rigg, T., Cawthron Institute.  
 Rout, W., Hardy Street.  
 Russell, J., Sunnybank, Bronte St.  
 Sadlier, Bishop, Wath Brow, Brougham Street.  
 Smith, C. M., Conservator of Forests, Trafalgar Street.  
 Taylor, J., 84 Haven Road  
 Tillyard, Dr. R. J., Maitai Lodge.  
 Wardrop, J. H., Lands Department.  
 Wharton, Miss B. A., Maitai Bank.  
 Wharton, Miss W. E., Maitai Bank.  
 Wharton, G. E., Maitai Bank.  
 Worley, Miss, Trafalgar Street South.

MANAWATU PHILOSOPHICAL SOCIETY.

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 Batchelar, J. O., Willow Bank.  
 Bayly, Mrs., Patea.  
 Bendall, W. E., Dairy Union.  
 Bennett, G. H., The Square.  
 Bett, D. H. B., M.B., Ch.B., M.R.C.S., M.R.C.P., Broad Street.  
 Blackburne, Rev. H. G., M.A., Vicarage.  
 Burges, A., 139 Featherston Street.  
 Callanan, F., Bainesse.  
 Cameron, W. B., 24 Russell Street.  
 Cameron, W. H. L., Queen Street.  
 Canton, H. J., Waldegrave Street.  
 Clausen, C. N., Rangitikei Street.  
 Cockayne, A. H., Wellington.  
 Cohen, M., Broad Street.  
 Collinson, L. H., The Square.  
 Crabb, E. H., College Street.  
 Cullen, Mrs., North Street.  
 Cunningham, G. H., Department of Agriculture.  
 Edwards, R., C.E., Duke Street.  
 Elliott, M. A., The Square.  
 Fitzherbert, W. L., Broad Street.  
 Fuller, R. A., Alexandra Street.  
 Gardner, Captain F. S., Bank of New Zealand, Sydney.\*  
 Gerrard, J. B., The Square.  
 Grace, R. H. F., National Bank.  
 Graham, A. J., The Square.  
 Grigor, A., National Bank.  
 Hannay, A., care of Manson and Barr.  
 Hepworth, H., The Square.  
 Hodder, T. R., Rangitikei Street.  
 Holben, E. R. B., Rangitikei Street.  
 Holbrook, H. W. F., 84 Rangitikei Street.  
 Hopwood, A., Main Street.  
 Hughes, J. R., C.E., The Square.  
 Hunter, W., 15 Rangitikei Street.  
 Hurley, E. O., The Square.  
 Johnston, J., Goring, Oakhurst.  
 Keeling, G. W., College Street W.  
 Larcomb, E., C.E., Roy Street.  
 Larcomb, P., Roy Street.  
 Mahon, A., The Square.  
 Merton, J. L. C., LL.B., Rangitikei Street.

- Miller, J., R.C.S.E., L.R.C.P.E.,  
     L.R.F.P. and S.G.  
 Mills, Miss C. B., M.A., Girls' High  
     School.  
 Moore, Miss  
 Murray, J., M.A., High School.  
 Nash, N. H., The Square.  
 Needham, F., Rangitikei Street.  
 Oakley, F. J., Rainforth Street.  
 Opie, F. D., Technical School.  
 Oram, M. H., M.A., LL.B., Rangitikei  
     Street.  
 Park, W., F.R.H.S., College Street.  
 Peach, Dr. C. W., M.B., C.M., Broad  
     Street.  
 Pigott, Miss E., 79 College Street.  
 Poynton, J. W., S.M., Auckland.\*  
 Ross, R., Ferguson Street.  
 Russell, W. W., Rangitikei Street.  
 Salmon, C. T., Assoc. in Eng., Can-  
     terbury College, Rangitikei Street.  
 Seifert, A., George Street.  
 Seifert, H., Featherston Street West.
- Seifert, L., George Street.  
 Sheppard, F. J., Rangitikei Street.  
 Sim, E. Grant, Rangitikei Street.  
 Sinclair, N. H., Allen Street.  
 Smith, W. W., F.E.S., Public Re-  
     serve, New Plymouth.  
 Stevens, J. H., Church Street.  
 Stevenson, J. C., High School.  
 Stowe, Dr. W. R., M.R.C.S., M.R.C.P.,  
     Linton Street.  
 Sutherland, A., Boundary Road.  
 Taylor, C., George Street.  
 Turner, W., Queen Street.  
 Welch, W., F.R.G.S., Mosman's Bay,  
     N.S.W.  
 West, E. V., King Street.  
 Whitaker, A., Grey Street.  
 Wilson, Miss D., Rangitikei Street.  
 Wilson, Miss E. Carncot, Rangitikei  
     Street.\*  
 Wood, J. R., Duke Street.  
 Wright, A. H. M., College Street.  
 Young, H. L., Cuba Street.

NOTE.—This list is not up to date, no revise having been supplied of that published in vol. 57.

SERIAL PUBLICATIONS RECEIVED BY THE LIBRARY OF  
THE NEW ZEALAND INSTITUTE, 1927.

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NEW ZEALAND.

Auckland University: *Calendar*.  
Geological Survey: *Bulletins*.  
Houses of Parliament: *Journals and Appendix*.  
*Journal of Agriculture*.  
*Journal of Science and Technology*.  
New Zealand Employers' Federation: *Industrial Bulletin*.  
*New Zealand Official Year-book*.  
Polynesian Society: *Journal*.  
*Statistics of New Zealand*.

AUSTRALIA.

Australasian Association for the Advancement of Science: *Report*.  
Australasian Institute of Mining Engineers: *Proceedings*.  
Australian Antarctic Expedition, 1911-14: *Reports*.  
*Australian Forestry Journal*.  
Commonwealth of Australia, Fisheries: *Parliamentary Report*.  
Institute of Science and Industry of Australia: *Bulletins*.  
Institution of Engineers of Australia: *Transactions; Quarterly Bulletin*.  
National Research Council of Australia: *Science Abstracts*.

NEW SOUTH WALES.

Agricultural Department, N.S.W.: *Agricultural Gazette*.  
Australian Museum, Sydney: *Records; Annual Report*.  
Botanic Gardens and Government Domains, N.S.W.: *Report*.  
*Critical Revision of the Genus Eucalyptus*.  
Department of Mines and Geological Survey: *Annual Report; Mineral Resources; Bulletins*.  
Linnean Society of N.S.W.: *Proceedings*.  
Northern Engineering Institute of N.S.W.: *Papers*.  
Public Health Department, N.S.W.: *Annual Report*.

QUEENSLAND.

Geological Survey of Queensland: *Publications*.  
*Queensland Naturalist*.  
Royal Geographical Society: *Journal*.  
Royal Society of Queensland: *Proceedings*.

SOUTH AUSTRALIA.

Adelaide Chamber of Commerce: *Annual Report*.  
Department of Chemistry, South Australia: *Bulletins*.  
Mines Department and Geological Survey of South Australia:  
*Mining Operations; G.S. Bulletins and Reports; Metallurgical*

*Reports; Synopsis of Mining Laws.*  
 Public Library, Museum, and Art Gallery of South Australia:  
*Annual Report.*  
 Royal Society of South Australia: *Transactions and Proceedings.*

## TASMANIA.

Mines Department, Hobart.  
 Royal Society of Tasmania: *Papers and Proceedings.*

## VICTORIA.

Advisory Committee: *Report on Brown Coal.*  
 Department of Agriculture: *Journal.*  
 Field Naturalists' Club of Victoria: *Victorian Naturalist.*  
 Mines Department and Geological Survey of Victoria: *Annual Report; Bulletins; Records.*  
 Public Library, Museum, and National Art Gallery of Victoria:  
*Annual Report.*  
 Royal Society of Victoria: *Proceedings.*

## WESTERN AUSTRALIA.

Geological Survey of Western Australia: *Bulletins.*  
 Royal Society of Western Australia: *Journal and Proceedings.*

## UNITED KINGDOM.

Board of Agriculture and Fisheries: *Fishery Investigations.*  
 Botanical Society of Edinburgh: *Transactions and Proceedings.*  
 British Association for the Advancement of Science: *Report.*  
 British Astronomical Association: *Journal; Memoirs; List of Members.*  
 British Museum: *Catalogues; Guides; Scientific Reports of British Antarctic Expedition, 1910.*  
 Cambridge Philosophical Society: *Proceedings, Biological Reviews.*  
 Cambridge University Library: *Report.*  
 Department of Scientific and Industrial Research: *Reports.*  
 Dove Marine Library: *Report.*  
 Durham Philosophical Society: *Proceedings; Agricultural and Zoological Publications.*  
 Edinburgh Geological Society: *Transactions.*  
 Geological Department, Glasgow University: *Papers; Monographs.*  
 Geological Society, Glasgow: *Transactions.*  
 Geological Society, London: *Quarterly Journal.*  
 Geological Survey of Great Britain: *Summary of Progress.*  
 Geologists Association, London: *Proceedings.*  
*Handbooks, Commercial Towns, England.*  
 H.M. Stationery Office, London: *Monthly Circular.*  
 Imperial Bureau of Entomology: *Review of Applied Entomology.*  
 Imperial Institute: *Bulletins.*  
 Institution of Civil Engineers: *Report.*  
 Leeds Geological Association: *Transactions.*

- Leeds Philosophical and Literary Society: *Annual Report*.  
 Linnean Society: *Journal* (Botany); *Proceedings*; *List of Members*.  
 Literary and Philosophical Society, Manchester: *Memoirs*.  
 Literary and Philosophical Society of Liverpool: *Proceedings*.  
 Liverpool Biological Society: *Proceedings*.  
 Liverpool Geological Society: *Proceedings*.  
 Marine Biological Association: *Journal*.  
 Marlborough College Natural History Society: *Reports*.  
*Mercantile Guardian*, London.  
 Mineralogical Society: *Mineralogical Magazine*.  
 North of England Institute of Mining and Mechanical Engineers:  
*Transactions*; *Annual Report*.  
 Oxford University: *Calendar*.  
 Royal Anthropological Institute of Great Britain: *Journal*.  
 Royal Botanic Gardens, Edinburgh: *Notes*.  
 Royal Colonial Institute: *United Empire*.  
 Royal Geographical Society: *Geographical Journal*.  
 Royal Irish Academy: *Proceedings*.  
 Royal Philosophical Society of Glasgow: *Proceedings*.  
 Royal Physical Society of Edinburgh: *Proceedings*.  
 Royal Scottish Geographical Society: *Scottish Geographical Magazine*.  
 Royal Society, Dublin: *Economic Proceedings*.  
 Royal Society of Edinburgh: *Proceedings*; *Transactions*.  
 Royal Society, London: *Proceedings* (Series A, B); *Phil. Trans.*  
 (Series A, B); *Year-book*.  
 Royal Society of Literature: *Transactions*.  
 Royal Statistical Society, London: *Journal*.  
 Victoria Institute, London: *Journal of Transactions*.  
 Zoological Society of London: *Proceedings and Transactions*.

#### AUSTRIA.

- Akademie der Wissenschaften in Wien: *Sitzungsberichte*.  
 Hofmuseum, Wien.  
 K.K. Central Anstalt für Meteorologie und Erdkunde, Vienna.  
 K.K. Geologischen Reichsanstalt, Vienna: *Verhandl.; Jahrb.*  
 K.K. Naturhistorischen Hofmuseums, Vienna: *Annalen*.  
 K.K. Zoologisch-Botanische Gesellschaft, Vienna: *Verhandl.*

#### BELGIUM.

- Académie Royale de Belgique: *Bulletins*.  
 Librairie Nationale d'Art et d'Histoire: *Les Cahiers belges*.  
 Musée Royal d'Histoire Naturelle de Belgique, Brussels: *Annales*;  
*Mémoires*.  
 Société Géologique de Belgique, Liege: *Publications*.  
 Société Royale de Botanique de Belgique: *Bulletins*.  
 Société Royale Zoologique et Malacologique de Belgique: *Annales*.  
 Société Scientifique de Brussels: *Annales*.

#### CENTRAL ASIA.

- University of Central Asia, Tashkent: *Bulletin*.

#### CHINA.

- Science Society of China, Nanking: *Publications*.

## DENMARK.

Acad. Roy. de Sciences et de Lettres de Denmark: *Forhandlinger; Memoires.*

Dansk Geologisk Forening, Copenhagen: *Meddelelser.*

Dansk. Naturh. Foren. Kjöbenhavn: *Videnskabelige Meddelelser.*

Danmarks Geologiske Undersøgelse, Copenhagen: *Publications.*

Kong. Dansk. Videnskab. Selskab.: *Forhandlinger; Skrifter.*

Zoological Museum, Copenhagen: *Danish-Ingolf Expedition.*

## FINLAND.

Academia Aboensis, Abo: *Humaniora.*

Finska Vetenskaps-Societeten: *Acta; Oversigt; Bidrag.*

Geological Commission of Finland: *Bulletin.*

Société de Géographie de Finland: *Fennia.*

Societas pro Fauna et Flora Fennica: *Meddelan; Acta.*

## FRANCE.

Le Prince Bonaparte, 10 Avenue d'Jena: *Notes.*

L'Observatoire Météorologique, Paris: *Annales.*

Ministre des Travaux Publics: *Programmes des Cours.*

Musée d'Histoire Naturelle, Paris: *Bulletins.*

Société Astronomique France: *Bulletin.*

Société de Chimie Industrielle, Paris: *Chimie et industries.*

Société de Géographie: *La Géographie.*

Société des Sciences Phys. et Naturelles, Bordeaux: *Memoires, Proc. Verb.*

Société Linneene de Bordeaux: *Publications.*

Société Linneene de Normandie, Caen: *Bulletin.*

Société Zoologique de France: *Bulletin.*

University of Grenoble: *Annales section Médecine.*

## GERMANY.

Botanische Verein der Provinz Brandenburg: *Verhandl.*

Bremer Wissenschaftlichen Gesellschaft: *Publications.*

Charles University, Prague: *Studies from Plant Physiological Laboratory.*

Der Sach Akademie der Wissenschaften, Leipzig: *Berichte; Abhandlungen.*

Deutschen Naturwissenschaften-medizinischen Verein für Bohem, Prague: *Abhandlungen; Lotos.*

Deutsches Entomologisches Museum, Berlin.

Ethnological Institute, Tübingen.

Geographie Kartographie, Leipzig: *Geographie Kartographie.*

Gesellschaft der Wissenschaften, Göttingen: *Nachrichten.*

Institut G.D. de Luxembourg, Naturelles Sciences Physiques and Mathématiques: *Archives.*

- Kong. Akademie der Wissenschaften, Munchen: *Sitzungsberichte, Abhandlungen*.
- Konigl. Zool. u. Anthro.-Ethno. Museum, Dresden.
- Kon. Preussische Geologischen Landesanstalt, Berlin: *Jahrbuch*.
- K.K. Zentral-Anstalt für Meteorologie und Geodynamik: *Jahrb.*
- Mathematische Gesellschaft, Berlin: *Sitzberichte*.
- National Museum (Entomological), Prague: *Sbornik*.
- Naturforschenden Gesellschaft, Freiburg: *Berichte*.
- Naturhistorische Gesellschaft, Hanover: *Jahrberichte*.
- Naturhistorisch Medizinischen Verein, Heidelberg: *Verhandlungen*.
- Naturhistorisches Museum, Hamburg: *Mitth.*
- Naturhistorische Verein der Preussischen Rheinlande und Westfalens, Bonn: *Verhandlungen; Sitzungsberichte*.
- Naturwissenschaftliche Verein für Schleswig-Holstein: *Schriften*.
- Oberheinischer Geologischer Verein, Tübingen.
- Physikalisch-Ökonomische Gesellschaft, Königsberg: *Schriften*.
- Preussische Akademie der Wissenschaften, Berlin: *Sitzberichte*.
- Preussische Geologische Landesanstalt, Berlin: *Jahrbuch*.
- Sächsische Akademie der Wissenschaften, Leipzig: *Berichte, Abhandlungen*.
- Senkenbergische Naturforschende Gesellschaft, Frankfurt-am-Main: *Berichte*.
- Staats und Universitätsbibliothek, Hamburg.

## HOLLAND AND DUTCH EAST INDIES.

- Banka Tin: *Jaaresverslag* von de Winning.
- Hollandse Maatschappij der Wet., Harlem: *Archives Neder.*
- Kon. Nederlandsch Aardrykskundig Genootschap (Royal Dutch Geographic Society): *Tijdschrift*.
- Kon. Bat. Genootschap van Wet., Batavia: *Verhand., Tijdschrift*.
- Koninklijk Akademie van Wet., Amsterdam: *Proceedings, Verhandlungen*.
- Koninklijke Naturkundige Vereeniging in Nederlandsch-Inde.
- Mijnwesen in Nederlandsh Oest-Indie, Batavia: *Jaarboek*.
- Nederlandsche Entomologische Vereeniging: *Tydschrift*.
- Rijks Ethnographisch Museum, Leiden: *Verslag*.
- Rijks Geologisch-Mineralogisch Museum, Leiden: *Geol. Meddelingen*.
- Société Hollandaise des Sciences, Haarlem: *Sciences Exactes*.

## HUNGARY.

- Botanisches Institut Museum and Garten, Szeged: *Folia Cryptogamica*.
- Magyar Tudományos Akadémia, Budapest: *Reports and Memoirs*.
- Hungarian National Museum, Budapest: *Annales*.

## ITALY.

- Accademia Scientifica Veneto-Trentino Istriana, Padova: *Atti*.
- Giornale Botanico Italiano, Nuovo*.
- Laboratorio di Zoologia Generale E. Agraria, Portice, Naples.
- Musei di Zoologia ed Anatomia Comp., Torino: *Bolletino*.

Reale Accademie dei Lincei, Rome: *Rendiconti*.

Reale Società Geographica, Roma: *Bollettino*.

*Revista Geographica Italiana*.

R. Istituto Veneto di Scienze, Lettere ed Arti, Venezia: *Atti; Memoirs*.

R. Ufficio Geologico d'Italia, Rome: *Bollettino*.

Società Africana d'Italia: *Bollettino*.

Società Botanica Italiana, Firenze: *Bollettino*.

Società Toscana di Scienze Naturali, Pisa: *Processi verbali*.

#### NORWAY.

Bergens Museum: *Aarbok; Aarberetning*.

Det Kongelige Fredriks Universitet, Christiania.

Norwegian Aurora Polaris Expedition, 1902-3.

Norwegian Meteorologischen Instituts, Kristiana: *Jahrb.*

Society of Arts and Sciences, Christiania (Oslo): *Scientific Results*.

Tromso Museum, Norway: *Annual Report, Annals, Memoirs*.

#### RUSSIA.

Biological Station, Saratov.

Comité Geologique de Russie, Leningrad: *Memoires*.

De la Société des Sciences et des Lettres de Vilno: *Travaux de l'Institut de Biologie Generale*.

Ichthyological Laboratory, Kerch: *Trudi*.

Imperial University of Youriev, Dorpat: *Revue Byzantine*.

Musée polonais d'hist. nat., Warsaw: *Zoological publications*.

Russian Entomological Society, Leningrad: *Revue Russe d'Entomologie*

Société Botanique de Pologne: *Acta Societatis*.

State University, Voronesh: *Trudi*.

#### SPAIN.

Instituto Botanico Universidade de Coimbra: *Boletin*.

Junta de Ciencias Naturals de Barcelona: *Serics botanica, geologica*.

Real Academia de Ciencias exactes, fisicas y naturales, Madrid: *Memorias*.

#### SWEDEN.

*Botaniska Notiser*, Lund.

Botaniska Tradgarden, Goteborg: *Bulletin*.

Entomologiska Foreningen, Stockholm: *Tidskrift*.

Geologiska Foreningens, Stockholm: *Forhandlingen*.

K. Universitet, Lund: *Acta*.

Kungl Svenska Vetenskapademiens, *Arkiv for*

Meteorologiske Iakttealser i Sverige.

Svenska Mosskultur Foreningen, Jonkoping: *Tidskrift*.

Svenska Naturskydds Foreningens Arsskrift, Stockholm: *Sveriges Natur*.

Svenska Sallskapet for Anthropologi och Geografi, Stockholm: *Geografiska Annaler*.

Sveriges Geologiska-Undersokning: *Arsbok*.

University of Lund: *Arsskrift*.

SWITZERLAND.

Musee d'Histoire Naturelle, Geneve.  
 Musei di Zoologia e Anatomia Comparata, Della R. Universita di  
 Genova: *Bolletino*.  
 Naturforschende Gesellschaft, Basel: *Verhandlungen*.  
 Naturforschende Gesellschaft, Bern: *Mittheilungen*.  
 Naturforschenden Gesellschaft, Zurich: *Vierteljahrschrift*.  
 Societa Elvetica delle Scienze Naturali, Bern: *Atti*.  
 Société de Physique et d'Histoire Naturelle de Geneve.  
*Verhandlungen der Naturforschenden Gesellschaft in Basel*.

INDIA AND CEYLON.

Agricultural Department, Calcutta: *Report on Progress of Agriculture*.  
 Agricultural Research Institute and College, Pusa: *Report*.  
 Anthropological Society, Bombay: *Journal*.  
 Asiatic Society of Bengal, Calcutta.  
 Board of Scientific Advice: *Annual Report*.  
 Botanic Survey of India, Sibpur, Calcutta: *Records*.  
*Ceylon Journal of Science*.  
 Colombo Museum: *Spolia Zeylanica*.  
 Geological Survey of India: *Records and Memoirs*.  
 Imperial Department of Agriculture, Pusa: *Reports, Review*.

JAPAN.

Department of Agriculture and Commerce, Yokohama: *Bulletin*.  
*Icones Plantarum Formosanarum*, Yaiihoku.  
 Imperial Earthquake Investigation Committee, Tokyo: *Bulletin*.  
 Imperial Geological Survey of Japan: *Report*.  
 Imperial University of Tokyo: *Journal of the College of Science*.  
 National Research Council of Japan: *Transactions and Abstracts*.  
 Tohoku Imperial University, Sendai: *Science Reports*.

MALAY STATES.

Java Ethnographischen Reichsmuseums: *Katalog*.  
*Malay States Government Gazette*.

TURKESTAN.

Scientific Society of Turkestan: *Transactions*.

EGYPT.

Ministry of Finance, Survey of Egypt, Cairo: *Bulletins*.

SOUTH AFRICA.

Cape of Good Hope Departments of Agriculture and Mines: *Reports*.  
 Durban Museum, Natal: *Annals*.

Geological Society of South Africa, Johannesburg: *Transactions*.  
 Natal Museum, Pietermaritzburg: *Annals*.  
 Natal Surveyor-General's Department: *Report*.  
 South African Association for the Advancement of Science: *South African Journal of Science*.  
 South African Museum: *Annals*.  
 Transvaal Mines Department: *Memoir*.  
 Transvaal Museum: *Annals*.  
 Union of South Africa, Mines Department Geological Survey: *Annual Reports; Memoirs*.

## CANADA.

Advisory Council for Scientific and Industrial Research: *Reports*.  
 Canadian Arctic Expedition, 1913-18: *Report*.  
 Canadian National Parks: *Booklets*.  
 Department of Naval Service: *Annual Report; Tide Tables*.  
 Department of the Interior: *Dominion Observatory Reports*.  
 Mines Department, Geological Survey Branch: *Memoirs; Summary Report; Museum Bulletin*.  
 Mines Department, Mines Branch: *Bulletins; Annual Report; other publications*.  
 Nova Scotian Institute of Science, Halifax: *Proceedings*.  
 Royal Canadian Institute, Toronto: *Transactions*.  
 Royal Society, Canada: *Proceedings and Transactions*.

## UNITED STATES.

Academy of Natural Sciences, Philadelphia: *Proceedings*.  
 Agricultural College Experiment Station, Michigan: *Reports; Bulletins*.  
 American Academy of Arts and Sciences: *Proceedings*.  
 American Geographical Society, New York: *Geographical Review*.  
 American Institute of Mining Engineers: *Transactions*.  
 American Journal of Philology.  
 American Museum of Natural History, New York: *Amer. Museum Novitates*.  
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